VOLUME 85, No. 4

STEAM GENERATION
POWER GENERATION
WATER POWER
DIESEL & GAS ENGINES
AIR CONDITIONING & HEATING
REFRIGERATION
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APRIL, 1941

Parkchester heating plant serves 12,000 families 58
The Old Chief honors the pre-stoker stokers 63
Mercury-steam power plant sets efficiency record 64
Jointless square-tubular bus system welded throughout 68
Combustion control holds steam pressure constant 70
16-page section on heating methods and equipment 73
How buildings lose heat . . 74 Heating equipment 80
Figuring heat loses . . . . . 76 Control equipment 86
Heating systems . . . . . 78 Operation 88
Parkchester in pictures—more photos of Bronx plant 89
Threading the hydro eye—handling turbine rotors 92
Design, construction and operation of gearmotors 93
5000-kw portable gas-turbine emergency power plant 96
Mingle's economical chimney sizes for natural draft 114
Suction and discharge conditions affect fan performance . . 120
Latest developments in lubrication of gas engines 130

THE OPERATING ENGINEER

How to make connections for draft-gage instruments 98
Boiler Explosions . . . . . 100 Homemade Meter 101
Practical Aids . . . . . 102 Readers' Problems 106
Headwork Section . . . . . 110 Argument Corner 111
How to put wire clips on wire rope—a photostory 112

OTHER DEPARTMENTS

Data Sheet No. 105 . . . . . 128 New Plant Equipment 132
George Edwards . . . . . 134 New Bulletins 163

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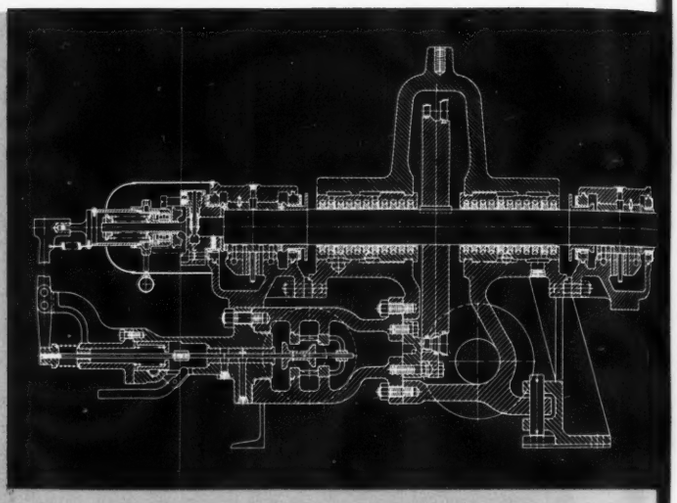
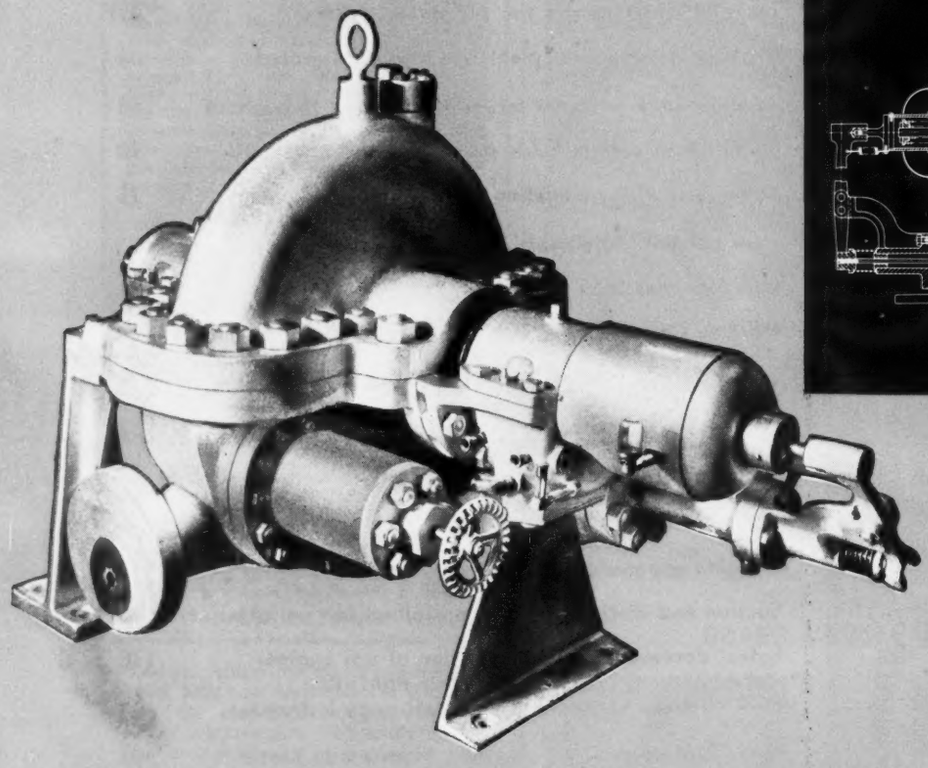
"little toppers"





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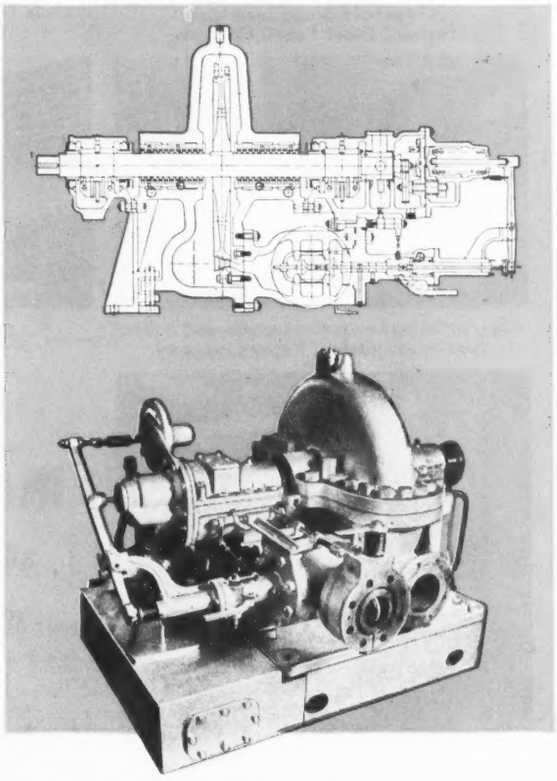

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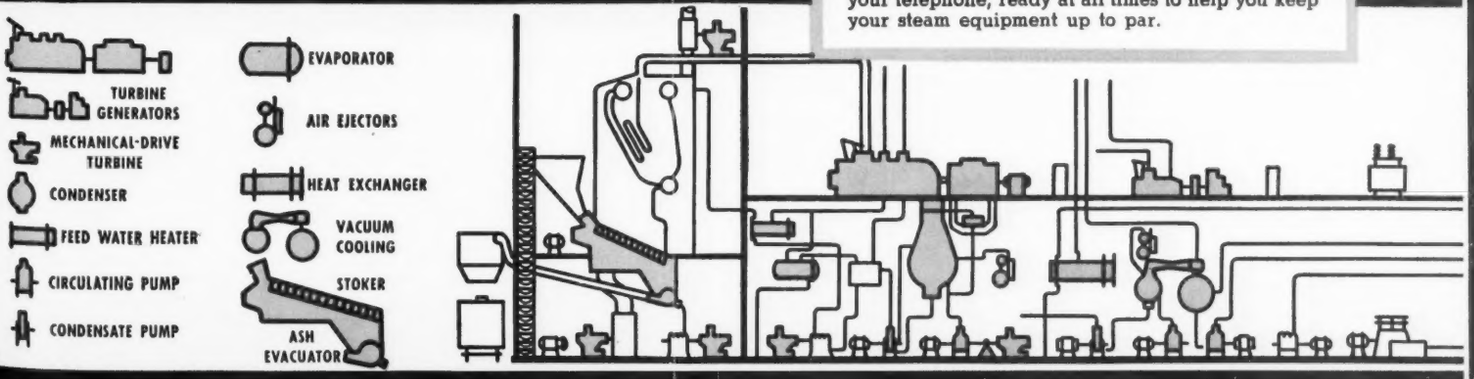

STEAM HEADQUARTERS

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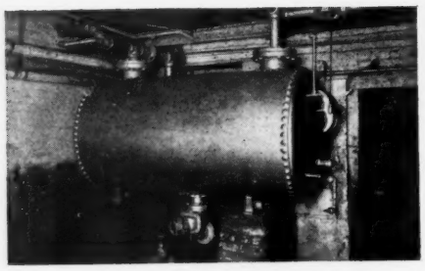
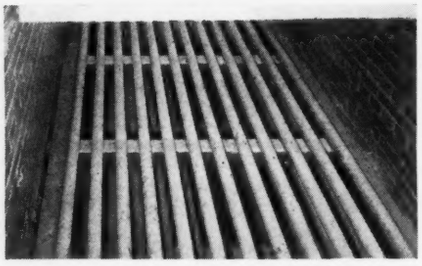
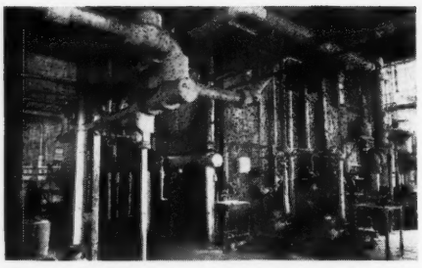


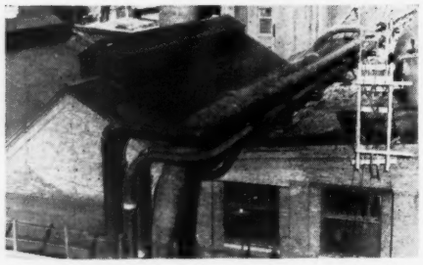
30-year-old boiler feed tank
Eberhard Faber Pencil Company



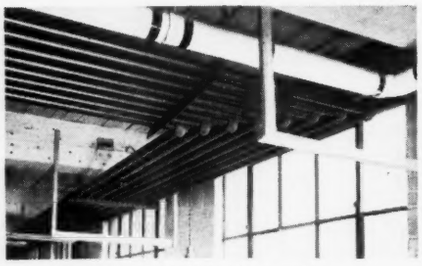
Coils in sand dryer—Central Silica Co.



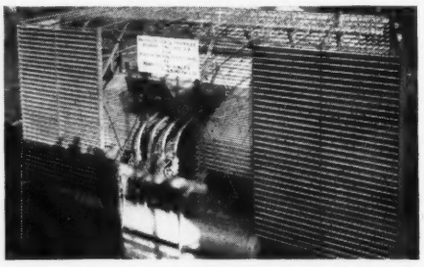
Boiler feed, heating return, hot and cold water lines—Page Milk Company



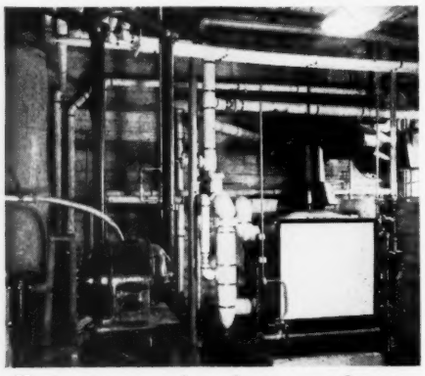
Gas, boiler make-up, condensate, and boiler feed lines—Oxford Paper Company



Overhead heating coils
Savage Arms Corporation

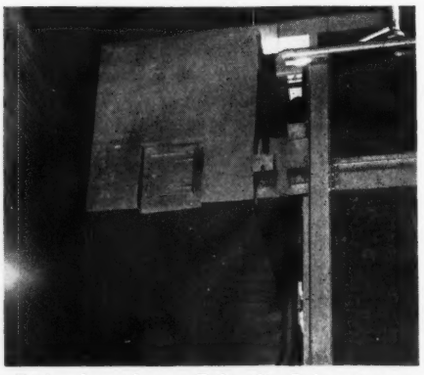


Pipe, sheets and plate in aerial condenser
Duquesne Brewing Company



Vents, steam supply and return, and waste lines—Standard Brands, Inc. of California

Proven defense against high maintenance costs in 101 services



Boiler breeching—Beltsville Laboratories, Department of Agriculture

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Maintenance and operating engineers are among the most enthusiastic users of wrought iron, for no one knows better how costly replacements can be. The illustrations show a few of the hundreds of places where they are using wrought iron. These services may suggest, to other engineers, places where the corrosion-resistance of Byers Wrought Iron can solve corrosion problems.

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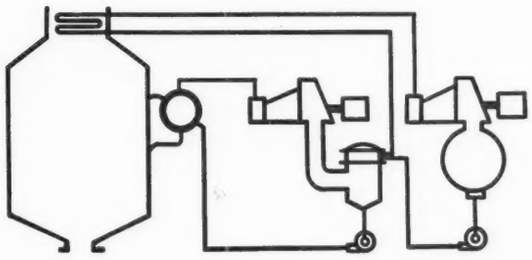
Established 1882 • PHILIP W SWAIN, Editor



Mercury-Steam Epic

After twenty-seven years of costly experimentation and hard work, mercury-steam power today assumes practical well-tested mechanical form at Kearny, N. J. (see page 64). Mercury power is man's closest approach to Carnot's ideal of a "perfect engine" receiving all its heat at the highest possible temperature level and rejecting all the unconverted heat at a low temperature level.

The boiling mercury at Kearny draws its latent heat from the furnace gases at about 960 F. Expansion, first of mercury vapor and then of steam, carries the temperature down to the heat-discharge level of the steam condenser—about 80 F. If Carnot were alive to study this operation, he would get the point—a wide span from top cycle temperature to bottom, with most of the absorbed heat taken in at the top and most of the waste heat discharged at the bottom—automatically a formula for high efficiency.

Beyond that, Carnot, no practical man, would be completely mystified. He never saw a turbine, knew little about boilers, never dreamed of mercury as a power fluid and would be totally incompetent to solve the hundreds of practical problems overcome by General Electric engineers in a quarter-century of mercury-steam pioneering. He would merely see, as others have, that the road from a brilliant idea to its practical accomplishment is long and hard, that the deep thinkers can create nothing without the hard doers who follow.

Where do we stand now? What is there to show for these years of toil and these millions of dollars spent by General Electric in bold experimentation? First, a large-scale mercury-steam power plant that runs as reliably as a good conventional steam plant. Second, the world's most efficient plant for conversion of fuel heat into kilowatt hours.

Good, but how about first cost? To that question we have no immediate answer, but we can point out a few thoughts worth considering. Not counting the cost of the mercury, and eliminating expenses properly chargeable to development, the present-day mercury-steam unit still costs substantially more than a high-pressure steam plant. How much more we don't know. Whatever the difference may be, time should reduce it.

Next we know that a mercury-steam plant must be initially charged with about 8 pounds of mercury per kilowatt and that the prewar cost of mercury was about one dollar per pound. When normal trade is restored after the war, the price of mercury should fall to one dollar or less—and design developments may cut the eight pounds per kilowatt. There is plenty of mercury ore, including much low-grade American, so we don't expect the mercury supply to be a limiting factor.

All things considered, we think the following a reasonable prediction for mercury power applications ten years hence: (1) new complete mercury-steam central stations, (2) mercury tops on existing high-pressure steam stations, (3) mercury teamed with process-steam production in industry, (4) perhaps mercury tied to condensing steam for ships and to non-condensing steam for locomotives.

Parkchester Heating Plant Serves 12,000-Family Housing Project

Modern boiler equipment and flexible layout, scientific water treatment and new streamlined convector heating system team to provide trouble-free operation for world's largest privately built apartment community

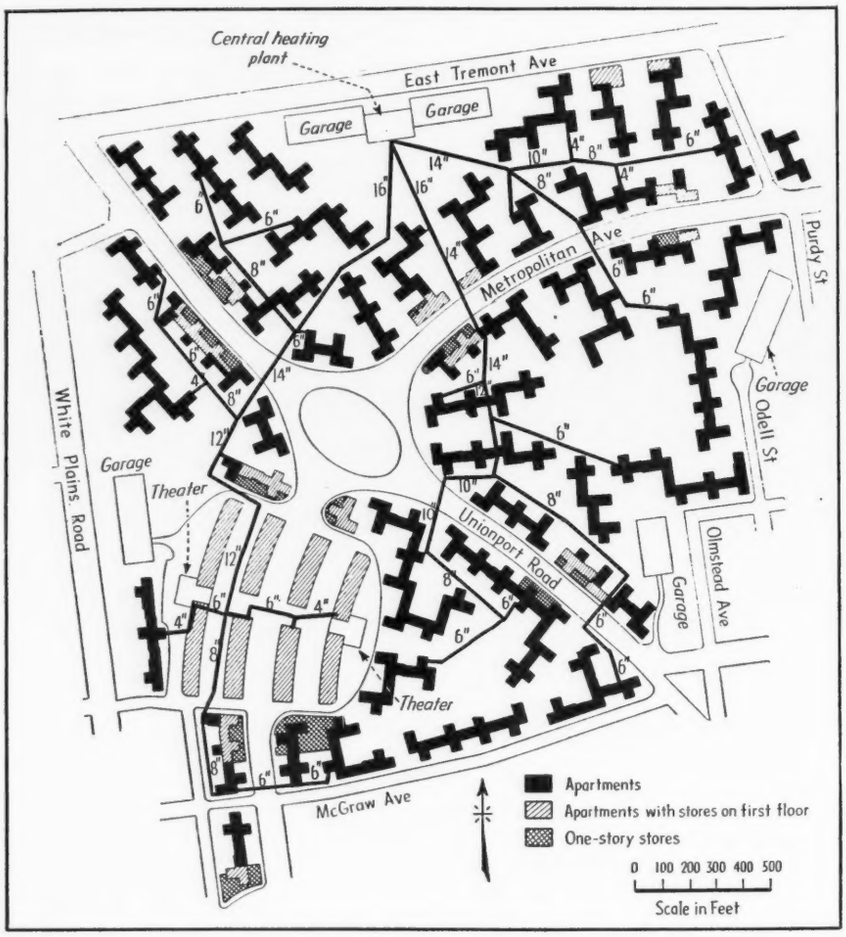


Fig. 1—Central heating plant supplies entire Parkchester development

▶ SIZE, IF NOTHING ELSE, would attract attention to the heating plant at Parkchester, Metropolitan Life Insurance Co's record-breaking apartment community in the Bronx, N. Y., but size coupled with foresighted and scrupulously careful design for economical and trouble-free operation makes an installation of outstanding engineering interest.

Believed to be the world's largest privately built housing project, Parkchester provides complete living facilities for 12,273 families. On 129.5 landscaped acres there are 171 dwelling units which average over eight stories in height, and all the shopping, recreational and garage facilities for modern living. The plot plan, Fig. 1, shows location of central plant which supplies steam and hot water to the entire development.

Boiler Equipment

Steam-generating equipment consists of four 135,000-lb-per-hr Foster Wheeler, 2-drum, bent-tube, oil-fired boilers, equipped with air preheaters. The cross-section, Fig. 3, shows space provided for a possible future switch to pulverized coal should relative fuel costs so dictate, and for power generation, should that later become desirable. Designed for 450-lb operation, the units now generate at 100 lb.

Tank trucks (2000-3000 gal) bring No. 6 oil to the plant at 100 to 150 F. A pipeline connection to a railroad siding across Tremont Avenue provides an alternate source. Four cylindrical underground storage tanks (240,000 gal total) hold a supply adequate for 15 days under normal winter conditions. Taken from one tank at a time, oil passes through a valve manifold and strainer before being pumped by one or more of four motor-driven, 25-gpm, high-pressure, Quimby screw pumps to one of three tubular heaters. A priming suction header, with two vacuum pumps good for 25 in., insures against loss of suction when changing tanks or when oil is low in tanks. Oil lines have air connections for backflushing to remove sludge.

Oil reaches the burners at 200-230 F; an additional strainer in the main oil-delivery line prevents foreign matter entering the burner tips. Individual coil heaters, supplied with exhaust steam, at the bottom of the four storage tanks, heat oil that may have become cold. A sludge pump removes accumulated sediment from tank bottoms.

Four wide-range Peabody burners, using a pump for differential control, fire each boiler. Burners point in a direction parallel to the drum centerlines, which are at right angles to the firing aisles. Gas describes a reverse path in the water-cooled furnace before entry to the tube banks (Fig. 4). A single Sturtevant duplex fan unit, driven by a 300-hp variable-speed turbine, serves each boiler, supplying both forced and induced draft. Fans and

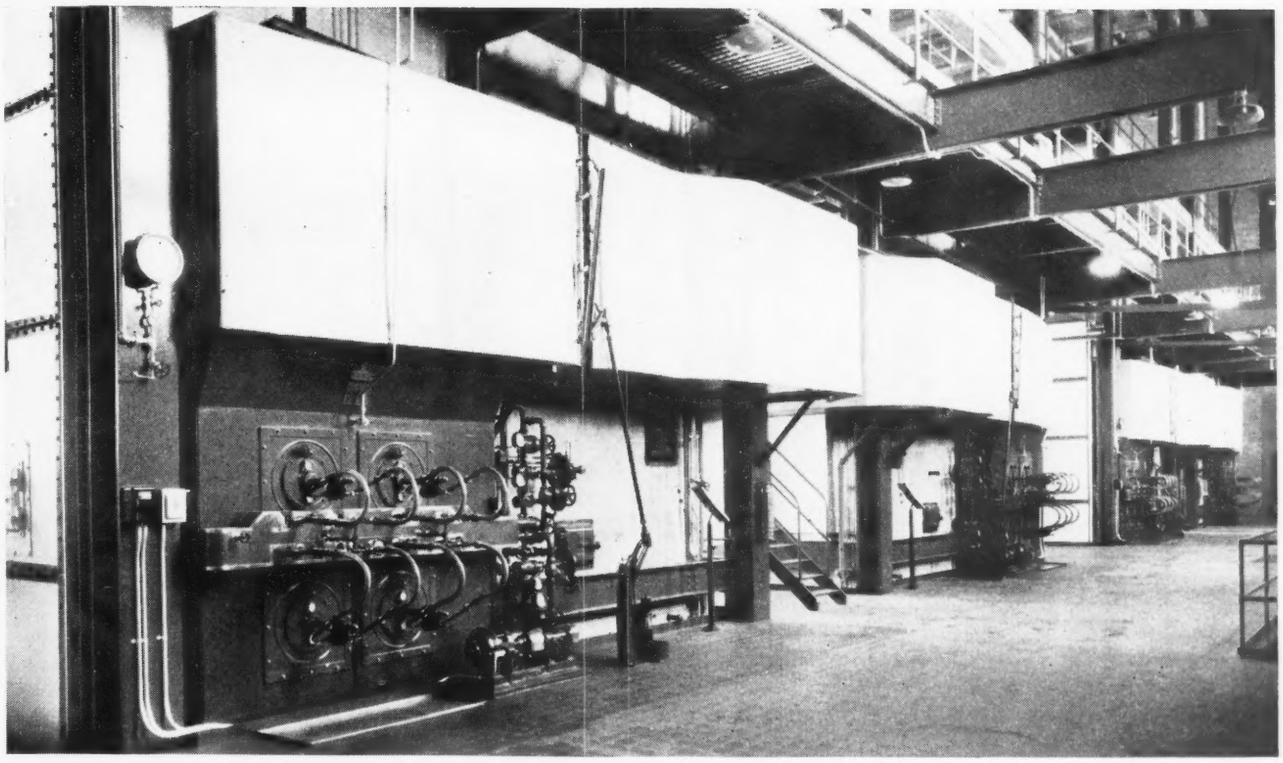


Fig. 2—Provision for possible future coal burning results in unusually spacious firing aisle

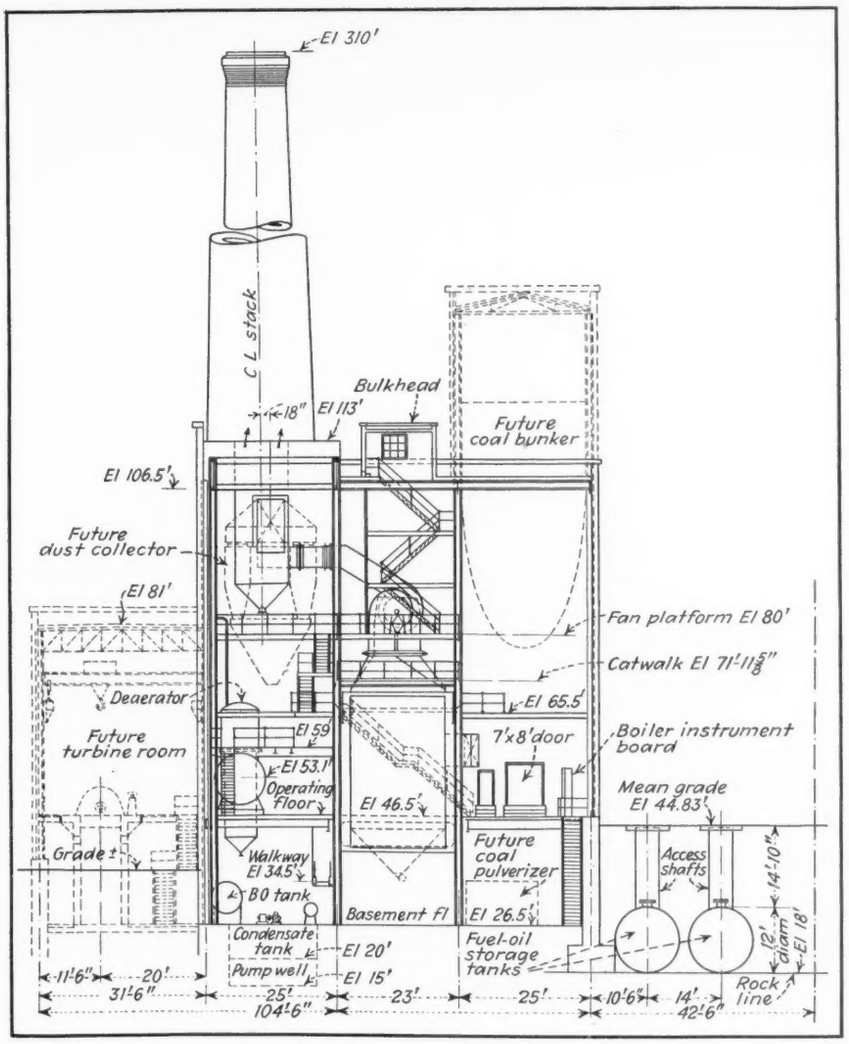


Fig. 3—Layout allows for possible pulverized-coal firing and power generation

turbines are large enough to handle increased gas flow of possible future pulverized-coal operation.

Heat balance of this plant differs considerably from that of a typical heating plant in that the ratio of peak space heating to peak hot-water heating is only about 3 to 2 instead of about 5 to 2. This results from certain design features of the heating installation, to be discussed later. The low ratio means a drastic reduction in the difference between winter peaks and summer loads, or in other words, a better load-factor. Along with other things, such as possibility of high-pressure operation, this load-factor improvement justified purchase of sufficient heat-absorbing surface to produce a fairly flat efficiency curve and a high average efficiency (about 85% under normal operating conditions).

Use of Exhaust

Steam-driven auxiliaries exhaust to the Elliott deaerating heater, Fig. 5. Exhaust needed varies, depending on proportion of hot-water condensate to space-heating condensate. When the former predominates, as in summer, temperature of returns is higher and so less exhaust is required. Two motor- and two turbine-driven boiler-feed pumps (Turbine Equipment Co) give the necessary flexibility.

At maximum loads and at extremely

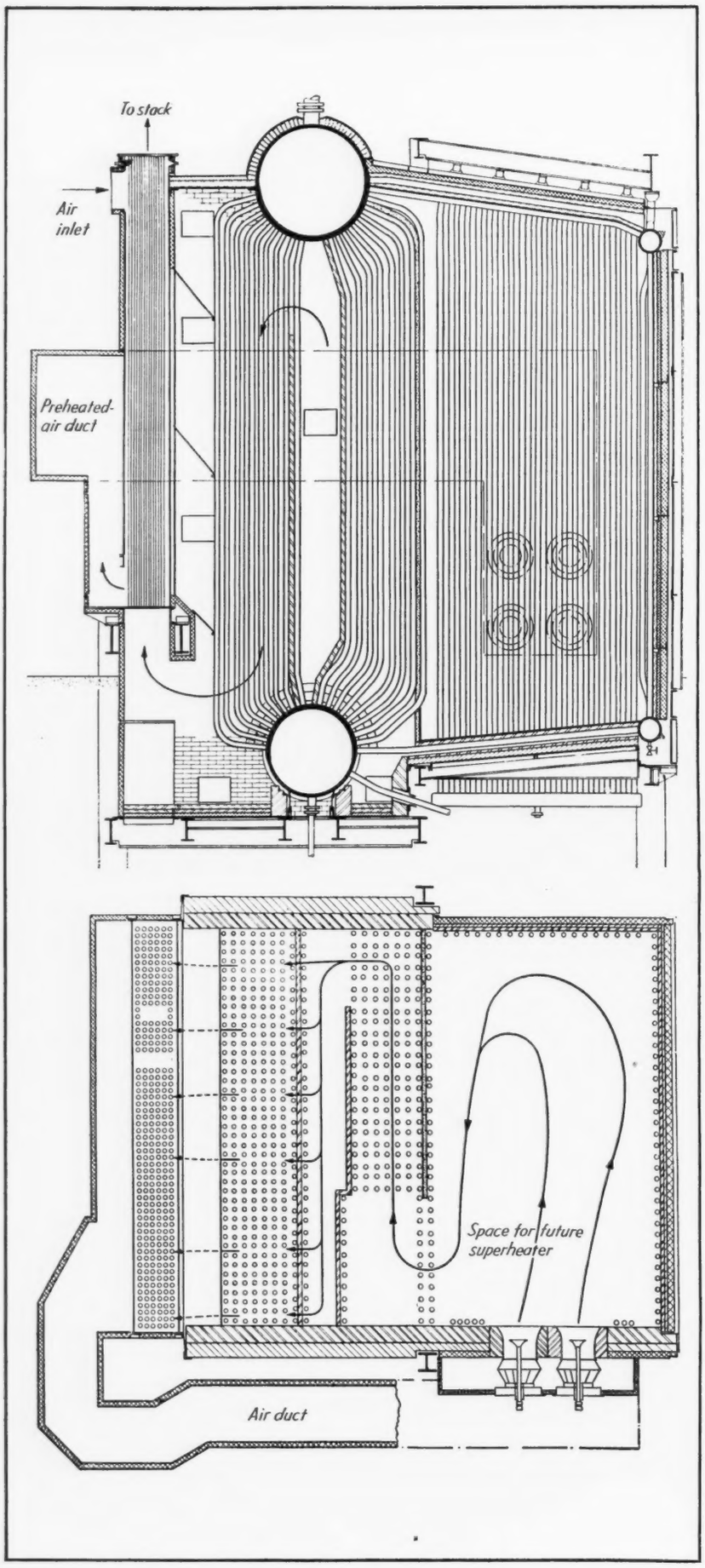


Fig. 4—Gas follows reverse path in compact, low-headroom, 2-drum boiler

light loads when the turbine-driven fans are not operated, the turbine-driven feed pumps balance the exhaust requirements. A tie between auxiliary-steam header and exhaust header, with a pressure-reducing valve set at 3 lb, insures steam for deaeration should auxiliary exhaust prove inadequate (Fig. 5).

Special conditions required some interesting modifications in boiler design. Specifications limited steam-water ratios in all tubes to safeguard against tube failure, and the maximum carryover was to be held to a small percentage at maximum load and with maximum permissible solids in the drum. To meet these requirements at the low initial operating pressure, the diameter of the top drum was increased to 72 in. and the number and diameter of circulators was increased. The design provides space for a future economizer to maintain efficiency in high-pressure operation, and for a convection superheater to deliver 600-F steam. The general layout, Fig. 4, represents an effort to obtain a high degree of furnace cooling in a compact low-head-room design.

Controls and Meters

A comprehensive control and metering installation is centralized in a master panel opposite the boiler fronts (see photos on page 89). The Bailey air-actuated control governs fuel-oil flow to the burners, fan-turbine speed and fan-damper position. Steam-transmission-line valves (electrically operated) can be opened or shut and electrically driven auxiliaries can be started or stopped from the main panel, which also mounts alarms indicating high or low water in the deaerator, low feedwater pressure, or lack of control-system compressed air.

Three main transmission lines (two 16 in. and one 14 in. diameter) feed from the steam header; these mains are of welded steel, insulated with double standard 85% magnesia, waterproofing and a copper jacket, and housed in poured-concrete ducts. Rollers and equally spaced guides support the pipe and control lateral movement; the expansion joints are packless welded Foster Wheeler units of special design. The mains reduce in diameter, at various stages, to 4 or 6 in. at entrance to heat-control rooms where pressure is reduced for circulation through building heating and hot-water supply tanks.

Pressure is reduced in a single step, but using two Leslie valves in series eliminated need for a relief valve and expensive relief piping. Normally the downstream valve regulates pressure; the upstream valve, set several ounces higher, stays open unless something goes wrong. A hand-operated bypass

permits maintenance without interrupting steam supply. Control rooms also contain Dunham vacuum and condensate-return pumps, and hot-water heaters. 29 control rooms serve the 171 dwelling units and six more supply the project's five garages and theater. Condensate returns to the boiler plant through approximately 14,000 linear ft of 85% copper piping, ranging from 1½ to 6 in. diameter.

To guard the enormous investment in transmission and heating equipment and to reduce operating difficulties and maintenance to a minimum, a comprehensive system of chemical control of the entire steam-water cycle was introduced, under direction of Shepard T Powell, consulting chemical engineer.

After preliminary treatment in a hot-process softener, city-water makeup goes to the storage tank of the main deaerator heater. The main condensate tank, completely Monel-lined to eliminate contamination from silica, etc, in bare concrete, takes all surges in the system. Four Turbine Equipment Co deepwell-type pumps lift condensate to the deaerator. Sodium sulphite removes traces of oxygen that might remain after mechanical deaeration, and injection of caustic soda for pH control of boiler feed is contemplated. Boiler-feed pumps take suction from the deaerator, discharging through Copes regulators to the boiler drums, where some phosphate is added, at present.

As dwelling units are completed and put into service, their heating systems receive thorough flushing. Water lost in this way increases makeup; at the beginning the percentage ran close to 100%, but it is now down to 15% and will drop to the design figure, 3%.

Steam-Quality Control

Thorough-going steam-quality control protects trap and control-valve mechanisms. Moisture eliminators in the boiler drums hold carryover to about 1 ppm total solids and a unique conductivity-recording installation provides a continuous check. Stainless-steel sample lines connect each boiler to a Leeds & Northrup recorder mounted in a specially designed steel case which contains the necessary cooling coil, automatic temperature control to hold a constant 77 F, and a Pyrex flow cell. Length and arrangement of sampling lines is carefully controlled (see Fig. 6) to drop steam pressure to 10 lb at the conductivity unit; there are no throttling valves in the sampling lines. A 30-in. vacuum in the flow cell removes CO_2 and reduces ammonia, thus eliminating need for a CO_2 correction and

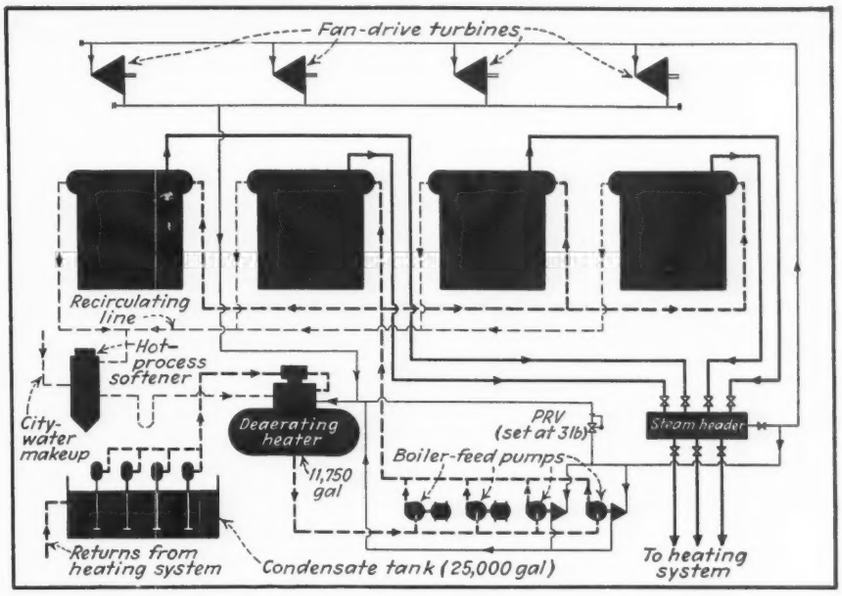


Fig. 5—Flow diagram shows how auxiliary exhausts provide deaerating steam

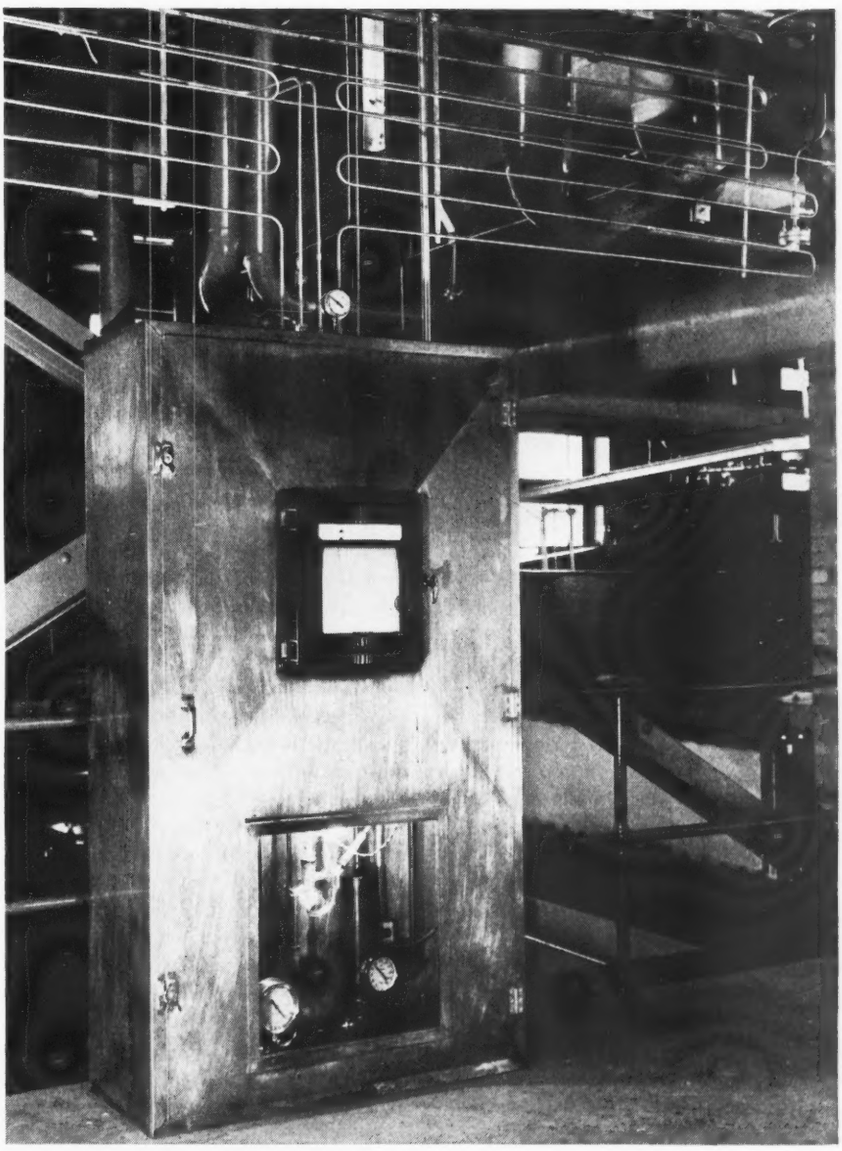


Fig. 6—Steel case houses conductivity recorder and accessories. Stainless-steel sampling lines (above) are coiled to give needed pressure drop

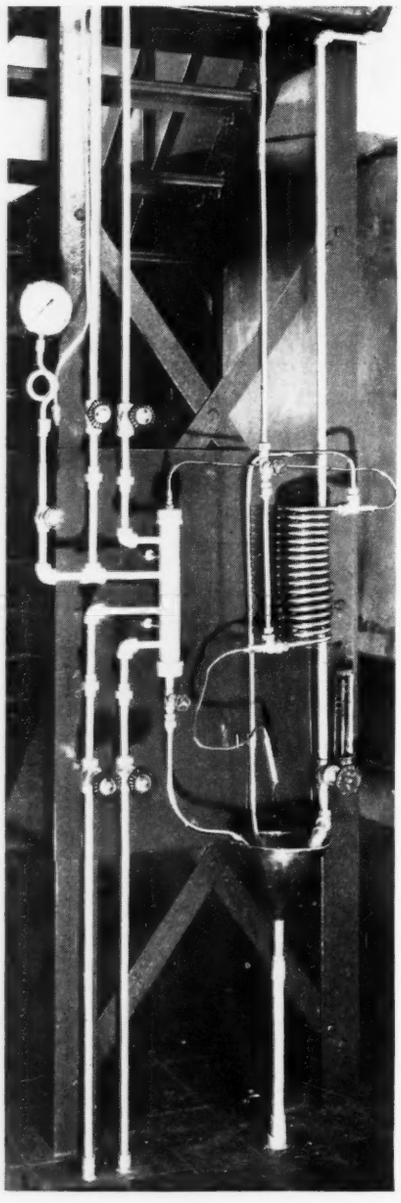


Fig. 7—A setup like this, for each pair of boilers, simplifies sampling

holding the ammonia correction to a minimum.

Water sampling lines from top and bottom drums of a pair of boilers connect to a convenient sampling setup (Fig. 7). In addition to the two on the operating floor, a third rig in the basement handles samples from condensate tank, softener outlet, boiler-feed suction, and three steam-distribution mains. Samples from all points are checked daily by the resident chemist, working in a completely equipped laboratory.

To protect vital continuity of service, standby water and power sources will be provided. A 30,000-gal city-water tank will insure against failure of the two present 8-in. mains serving the heating plant, and by storing oil-cooler cooling-water returns, now wasted to sewer, will effect some saving in water consumption. A 100-kw gasoline-engine generator set will supply emergency lighting and power for heating-plant auxiliaries.

Design for efficient heating started with the buildings themselves. Studies of economic balance between investment and fuel cost indicated a saving could be made by adding a 1-in. layer of glass wool, with vapor stop, between interior plaster and waterproofed-brick exterior wall. The resulting higher plaster temperature will reduce body radiation absorption usually experienced where cold wall surfaces exist, and thus increase comfort. This insulation produces a substantial reduction in steam requirements, bringing the ratio of peak space heating to peak hot-water heating down to 3 to 2.

A simplified form of steam-heating, specially developed for the project, kept investment to a minimum and reduces cost of operation and maintenance. The sketch, Fig. 8, shows a typical section, featuring a 1-pipe looped, valveless hookup yielding utmost tightness and simplicity. Steam flows up the single riser, through kitchens and bathrooms, and descends through a series of convectors connected by exposed vertical pipes running beside the window frames. A single trap in the basement handles returns from all convectors on a single loop.

Schedules

Heating steam is supplied from the boiler plant according to a carefully worked-out schedule; in extremely cold weather, the "heat-on" period is increased and heat may be supplied all night, at reduced rates. During the "heat-on" period, steam pressure is modulated by outdoor thermostats within a range from 2 lb to about 27 in. vacuum. An indoor thermostat in a selected representative position acts as an over-riding control. A damper built into the concealing enclosure on each convector permits individual adjustment down to 50% of convector output.

An operating building adjacent to the heating plant will house a machine shop, with welding and forge rooms, and electrical, plumbing and carpenter shops. From the operating-department offices on the 2nd floor, the manifold maintenance activities will be directed.

General responsibility for operation and maintenance falls on Rix R McDavid, operating superintendent. John A Dondero, chief engineer, heads up mechanical operation and maintenance, with Richard H Richardson, assistant chief engineer, in charge of the boiler plant, and Walter E DeWaal, control-room engineer, in charge of the heating system. Burns & Roe, Inc, New York, were consulting engineers on the boiler-plant and transmission-system design; Baker, Smith and Co, New York, designed the heating system and were the contractors for both boiler plant and heating system. Henry C Meyer Jr, of Meyer, Strong & Jones Inc, was a member of the board of design for the housing project and the board's adviser on mechanical engineering work.

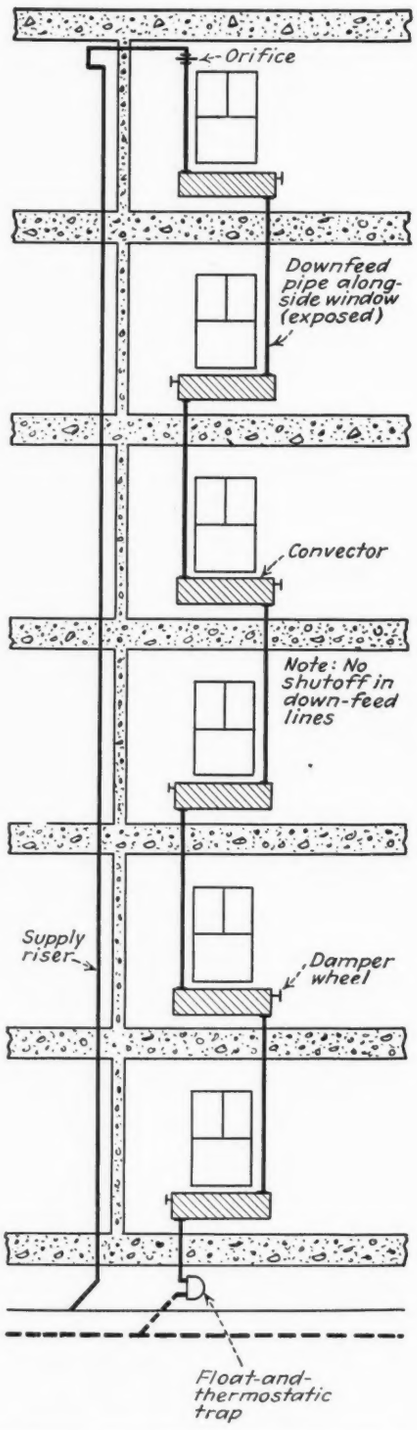


Fig. 8—Typical section shows 1-pipe looped valveless convector heating

THE OLD CHIEF

VI—Pre-Stoker Stokers

Sixth in a series of reminiscences by William Doran, chief engineer, Essex County Sanatorium, Windsor, Ontario. Writing of the inspiration of the past, he has captured much of the human side of engineering that lies beneath the maze of power-plant costs and the wavy lines on paper disks

I'm a stoker, I'm a stoker;
I work with a shovel and a poker
Where the heat and the smell
Are just like hell—
No wonder I'm an awful soaker!
(*Old song*)

▶I BELIEVE that if the old Chief had one soft spot in his heart, it was reserved for trustworthy firemen. He would encourage and help them in their studies and was never slow in bestowing a word of praise when their skill deserved it. He would sometimes even go so far as to overlook their slight tipsiness or inevitable hangovers.

In the day of which I write, it was usual for two men per shift to work five boilers. New men were hired with an eye to their brawn and muscle; in fact, the broadness of their backs found more favor in the eyes of the Chief than did their knowledge of "Dulong's formula."

The Job Calls for Skill

Out in the front office, firemen were classed as unskilled labor, that is, as far as their wages were concerned. Actually though, the fireman's job called for uncanny skill in manhandling a fire, manual control of the drafts and dampers, and constant vigilance required to watch the twenty and one things that are now done by twenty and one automatic devices.

In no calling, save perhaps glass blowing, did the work call for so much dexerity, skill and backbreaking toil as did the fireman's job in an overloaded plant at the turn of the century. The experienced fireman never seemed to be in a hurry about anything; he moved from chore to chore methodically. He would "wing" over one side of the fire, run an ungodly heavy slice bar under the clinkers, throw in the heavy rake, pull them out, and then proceed with the other side.

Next, he would pitch in coal to an even depth, depending on load and the pressure line. A good fireman could throw a shovel full of coal into a pail 20 feet away, without spilling an ounce, if someone would bet him a drink on it. "Punching" the tubes was an ordeal, because for some unknown reason the man who designed the boilers made no provision for punching them from the rear, that is, with the natural draft of the boiler. So the poor fireman had to stand in front of the boiler on a rickety platform and eat soot and dust for an hour.

You could tell the time of day by what the firemen were doing—blowing down, wheeling coal, trimming coal, moving and hoisting ashes, or tending the old feed pump with its overhead crank and its thumping noise. The pressure line was their constant care and blowholes in the fire the bane of their existence. When the load was extra heavy or some breakdown occurred, I have seen the Old Chief peel off his coat and work, chore for chore, with the firemen until the pressure line was right. It is interesting to reflect that such occasions were the only times I ever saw the Old Chief chew tobacco. The very action of his borrowing a man-size chew from one of the firemen was a signal that he was about to help out or break in a rookie fireman.

We had from time to time some good firemen who had no desire to find a softer job. They had grown up with the game and when they reached the stage when they were known and recognized as solid men, they sought no higher honor. I remember one tough old fireman who was working with a bad cold. He regarded it more as a bothersome thing that was interfering with his work than as an illness. Exasperated and out of patience, he treated himself with a finger of kerosene every two hours. His cure would probably have sent me to the nearest hospital, but he was back on the job the next day minus his cold.

In every city throughout the country you will see in our art galleries, on the facades of banks and state buildings, and in other prominent places grand and noble statues honoring our sturdy pioneers, usually depicted by a broad-shouldered man with a plow and a team of oxen, engaged in wresting a living from the virgin soil. It is indeed fitting that we should so honor the vision and valor of our forefathers.

"A statue in gleaming bronze of a fireman"

Perhaps on some future day they will review the human story behind our industrial history, when, I hope, there will be unveiled a statue in gleaming bronze of a fireman breaking open the way for industry with a huge slice bar. And, oh yes, there should be a few beautiful goddesses hovering over him with overflowing pitchers of nectar to assuage his thirst.

Mercury Unit Sets Efficiency Record

From porcupine tube to fog bank and furnace wall, the mercury-vapor process has developed step by step into the world's most efficient power-generating unit. New boiler design has completed nearly a year of operation at Kearny, N. J. Developments are summarized from a technical paper by A R Smith and E S Thompson, General Electric Co

▶ NEARLY 30 YEARS of patient research and field experiment have brought the mechanical problems of the mercury-vapor cycle to a point where the designers are thinking about future applications instead of actual present troubles. The mercury-turbine-boiler unit had to start from scratch—even the properties of mercury had to be determined.

Now, however, 13 years' experience on the 10,000-kw unit at Hartford, eight years on the outdoor plant at Schenectady, and almost a year on a single-drum mercury-wall boiler at Kearny, have provided ample proof. The mercury-vapor cycle has become a practical operating assembly of tested mechanical equipment which, when combined with modern steam turbines, represents the most efficient electric power-generating unit yet known.

Only Tops So Far

All the mercury equipment built so far has topped steam units, without doubt the widest field of application. While the highest-pressure steam so far utilized from the mercury condenser-boiler has been on the order of 400 lb, mercury equipment can be superposed on steam units of any operating pressure and temperature.

With mercury superposed over 600-lb, 730-F steam, 7250 kw can be generated per 100,000 lb per hr of steam produced in the condenser-boiler, whereas a superposed steam turbine at 1200-lb, 925-F, can generate only 1960 kw. Calculations show that mercury can make 5650 kw per 100,000 lb per hr of steam at 1200 lb, 925 F. For industrial plants requiring process steam at any pressure mercury furnishes a greater amount of byproduct power for a given steam flow than any other power cycle.

The mercury cycle can be considered a steam producer which, for a given amount of fuel, makes nearly as much steam as would a boiler. In addition, byproduct power is obtained from the mercury turbine. Such power is generated from little more than the equivalent of the thermal energy, of the order of 4000 Btu per kwhr.

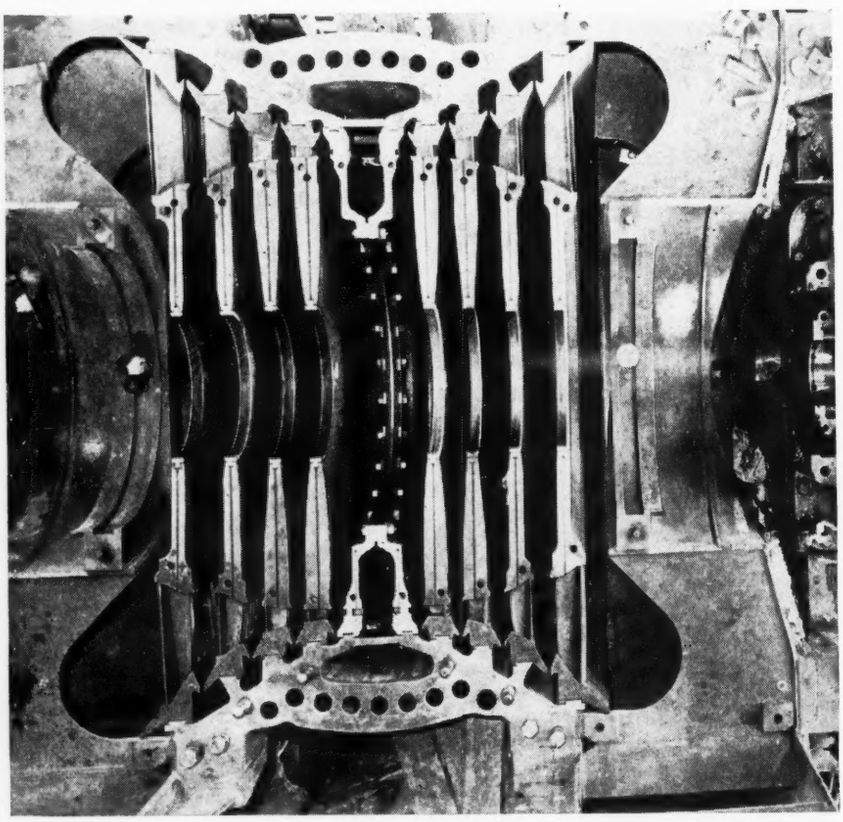


Fig. 1—Lower half of turbine casing of 20,000-kw double-flow mercury turbine after five years of service. It is now equipped with new-type shaft seal which holds air leakage down to 0.4 cu ft per hr

Mercury is vaporized in a boiler at comparatively low pressure, 140 lb at Kearny, and passes through a mercury turbine, Fig. 1, which drives a generator, see Fig. 3. The vapor from the turbine is exhausted to a condenser-boiler where its latent heat is transferred to water, making steam at any desired pressure. This steam is returned to superheaters in the gas passages of the mercury boiler and then used in steam turbines or process. The mercury condenser-boiler is in effect an evaporator and can use poorer water than can be tolerated by a corresponding steam boiler fired by fuel.

All known fluids for use as the top fluid in a binary cycle have been investigated and, with the exception of mercury, have been found lacking in some of the fundamental requirements. Mercury has many advantages. It boils at 140 lb at a temperature of 975 F, 300 lb at 1100 F. Its critical temperature is about 2240 F. It is stable at temperatures above those that boiler and turbine materials can take. There is no danger of it solidifying in the boiler tubes, as is the case with many other top fluids, since the freezing point

of liquid mercury is about —38 F.

The first mercury boiler, a single tube containing a solid core, operated in 1912. It demonstrated that high circulation rates were necessary because the mercury did not wet the heating surface. Several experimental boilers were built at Schenectady of various capacities and designs. High temperatures made tight rolled joints impossible.

The first installation at the Dutch Point Station of Hartford Electric Light Co in 1922 was designed to deliver 1800 kw and 40,000 lb per hr of steam at 200-lb pressure, 100-F superheat. Suspended porcupine tubes were developed for this boiler in 1925. The original single-stage turbine was replaced by a 3-stage unit with overhung rotor to eliminate a high-pressure packing.

The 10,000-kw mercury unit now operating at South Meadow Station, Hartford, was installed in 1928. It has operated 72,000 hours, the equivalent of eight full years, in about twelve years elapsed time. The average heat rate of the mercury plant, including the calculated effect of the steam cycle on which it is superposed, for the years 1938 and 1939, was 10,000 Btu per net kwhr.

Two Plants in 1932

Two plants were built in 1932, one for the Schenectady Works of the General Electric Co and the other for the Kearny Station of the Public Service Electric & Gas Co of New Jersey. Each was a 20,000-kw mercury turbine. Mercury pressure was increased to 140-lb compared with 85-lb at Hartford. The boilers had porcupine tubes set in seven drums, but wall tubes, embedded in copper to obtain more uniform heat transfer, were a new feature. Water walls, however, formed the lower part of the furnace, generating steam at 400-lb.

All mercury units except Schenectady have the turbine mounted above the boiler for gravity return of the mercury to the boiler. For the Schenectady outdoor unit, liquid mercury is returned by a centrifugal pump requiring only 8 hp per 1000 kw of mercury-turbine rating. This unit is now in regular operation, and, though the turbine-generator, condenser-boiler and a steam turbine with their usual auxiliaries are exposed, the plant has passed several severe winters without any operating difficulties.

The only changes made in the Schenectady unit in the 7-year period of operation have been the replacement of the liquid heater above the drums by a

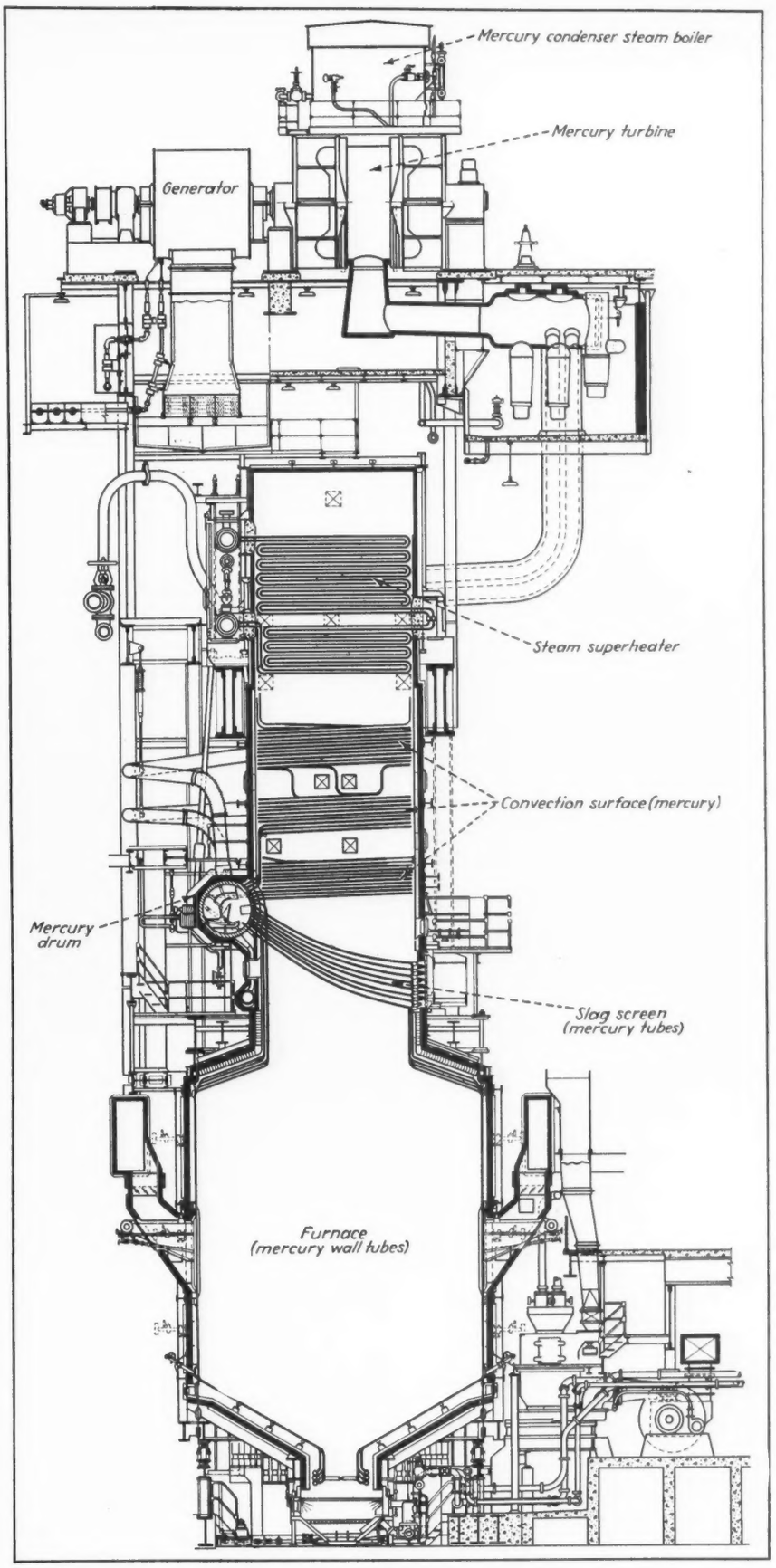


Fig. 2—General Electric mercury boiler installed at the Kearny Station of the Public Service Electric & Gas Co of N. J. in 1940. A complete mercury-wall enclosure of the furnace and a single drum replace older-type porcupine tubes and seven drums. New type mercury convection surface, the so-called "fog bank," contains less liquid mercury per unit of heat absorbed than any previous design

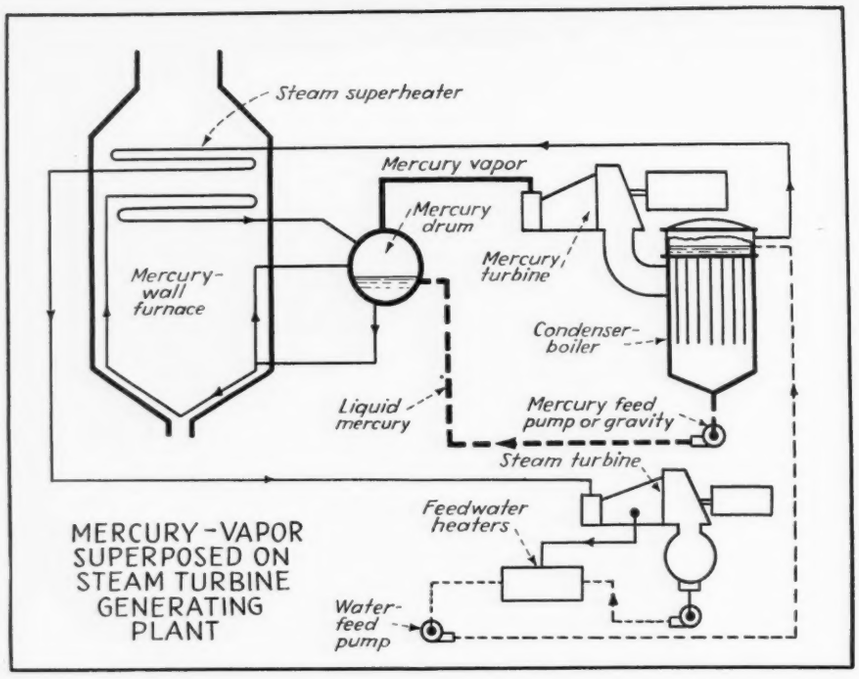


Fig. 3—Mercury-vapor cycle can top steam at any desired pressure and temperature. Heat is exchanged from mercury to steam in condenser-boilers

mercury convection surface and a change to the condenser-boiler tubes in which adjacent dead-end tubes were connected to improve circulation.

The original mercury plant installed at Kearny first operated in March, 1933. The boiler, turbine and condenser-boilers were duplicates of those at Schenectady. This unit was operated until September, 1938, when the boiler was removed to make way for a new one of advanced design, which began operating May 5, 1940. This boiler design was evolved after a great amount of laboratory research and the construction of several small mercury units.

Forced-Circulation Boiler

An interesting development was a 1000-kw forced-circulation boiler tested in Schenectady. The firebox was formed of helically wound tubes forming a cylindrical combustion chamber. For a short distance above the bottom of the firebox the tubes were open spaced to allow the gas to pass out and up through a concentric mercury liquid heater and steam superheater. After leaving the steam superheater the gas passed through a 2-pass air preheater to the stack. Mercury was pumped through the radiation tubes and discharged to a separator containing nozzles in which the vapor was formed by flashing due to release of pressure.

Based on this experience, a unit mercury power plant was built in 1937 for the River Works of the General Electric Co at Lynn, Mass., composed of elements which could be completely assembled in the factory, thus requiring a minimum of expense for field erection.

The unit could be started and stopped rapidly with no danger of unequal heating of tubes. It operated successfully for 6000 hours, carrying full load without difficulty. When sufficient experience had been gained with the boiler, the plant was shut down in August, 1939. One advantage of the forced-circulation boiler is that the firebox and the tube circuits can conform to confined spaces such as are typical of ships and locomotives.

Another small boiler was installed at the Pittsfield, Mass., Works of the General Electric Co in 1937 to study the action of relatively high vertical wall tubes with natural or thermal circulation. Most of the advances in treatment of mercury were tried on this unit. The generator, mercury turbine, valves and condenser-boiler for this unit were those from the original Dutch Point installation. They performed admirably during the 2-year testing period.

The new boiler at Kearny has only a single drum instead of the seven of the previous unit. Furnace walls of practically contiguous mercury tubes serve as primary heat-absorbing surface in place of the porcupine tubes characteristic of mercury boilers for many years. The new boiler, Fig. 2, occupies the same space as the old unit. The octagonal-shaped furnace conserves mercury and tends to equalize the heat absorbed by all tubes. Burners, equipped for either coal or oil, on each of the eight sides provide a uniformly distributed flame by proper selection of burners throughout the load range.

Insufficient experience was available at the time the original Kearny boiler was built as to the pumping, or circulating, ability of high vertical furnace-wall tubes. The Hartford boiler had no mercury wall, Kearny original and Schenectady boilers had upper-half mercury and lower-half water walls; the new furnace completes the evolution of the tubular-lined firebox similar to modern steam generators.

Every new design detail of this boiler was adopted only after exhaustive tests on full-scale models with water-air mixtures, mercury-air mixtures and under actual fired conditions with mercury vapor being formed. This care has resulted in excellent performance of the equipment from the first day of operation to the present.

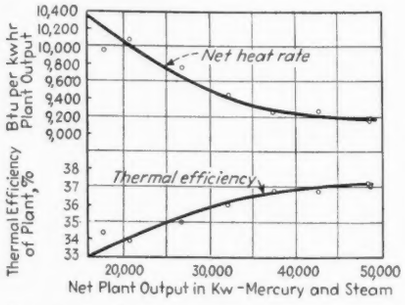


Fig. 4—Performance test of Kearny unit indicates highest thermal efficiency of any electric power-generating plant

The porcupine tubes were ingenious in design and functioned quite well, but the small passages were a potential source of plugging by foreign material and they were hard to clean as well as expensive to manufacture. By substituting wall tubes for porcupine-tube surface, it became possible to remove the complication of seven drums which involved equalizing difficulties and other disadvantageous features. The new boiler has a single 54-in. drum, 4½ in. thick, 30 ft long weighing 90,000 lb. A section through the drum, Fig. 5, shows the baffle arrangement which allows no measureable carryover of liquid. The pressure drop from drum to turbine produces about 30 F superheat in the vapor.

The catenary shape of the upper end of the wall tubes helps keep the stresses low. The convection surface, the so-called fog bank, above consists of six bundles of tubes, separated for soot blowers and accessibility. Tubes are held individually by supports cooled by water circulating thermally from the condenser-boilers on the floor above.

Thermal circulating action in 180 of

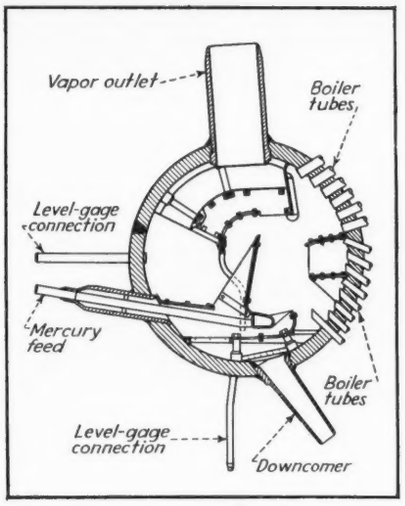


Fig. 5—Section through boiler drum showing baffle arrangement for eliminating carryover of mercury liquid

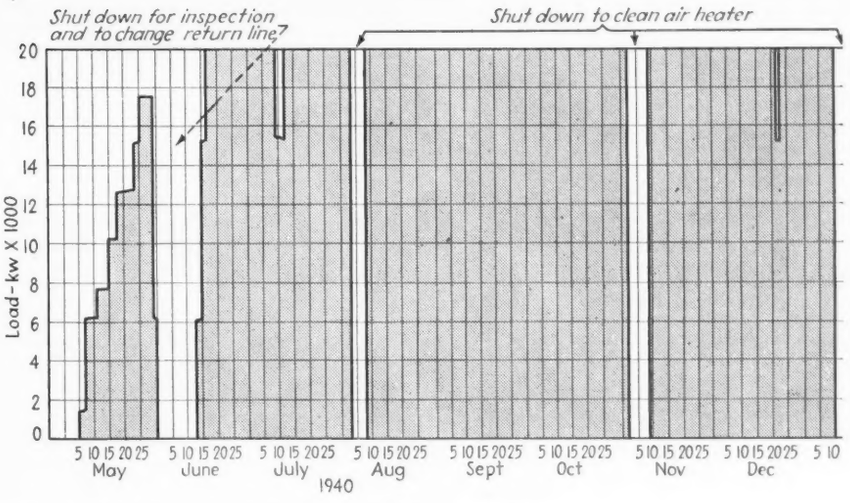


Fig. 6—Operating record indicates high degree of reliability for mercury unit for nearly a year, much of the time at full load.

the mercury-wall tubes lifts the mixture of liquid and vapor to the top of the convection tube banks from where the mixture flows back to the drum by a combination of pressure drop and gravity head. When the boiler is cold, all the mercury normally in the tube bank drains back into the drum because of the constant hydraulic grade from top to bottom.

Mercury per Kw

The new boiler contains 392,000 lb of mercury. The 20,000 kw output of the mercury turbine adds to 30,000 kw from steam generated in the condenser-boiler. Auxiliary equipment requires about 1200 kw. Total mercury in the boiler is then eight lb per net kw.

The convection surface is empty when cold but, in service, is filled with a mixture of liquid and vapor, mostly vapor. It is believed that an extension of this principle of mixture-filled tubes to the hotter parts of the furnace would materially reduce the amount of mercury needed in future designs so that its cost and availability would be less important factors.

The design of this boiler in so far as the functioning of the mercury is concerned was conceived by the General Electric Co. The mechanical design, combustion facilities, building and erection were done by the Babcock & Wilcox Co.

There are approximately 5000 field and factory welds in the boiler and no leaks were found in the hydrostatic test or during operation. Operation has been at full load practically all the time, Fig. 6. Firing has been by oil for the most part. Because of the unusual boiler design and the temperatures at which the tubes work, coal firing is being tried out to find the nature and location of slag deposits before installing soot blowers.

The good condition of the mercury turbine after five years' service can be seen from Fig. 1. A special carbon-ring liquid-seal packing keeps air leakage below 0.4 cu ft per hr. During operation a Kinney vacuum pump is used but steam-jet air ejectors bring the system down to an absolute pressure of 0.4 in. Hg for starting.

A mercury impact cleaner for removing dirt and solids from the mercury consists of a sump and dirt-collector tank. Any heavy foreign material, such as welding beads, is washed into and held behind the dam around the inside of the sump.

A tank in the basement can store the entire quantity of mercury. In the event of a leak, two emergency valves can be opened to allow the liquid to drain rapidly through a cooler to the tank. A small pump in this tank returns the mercury to the boiler.

Thermocouples tell the temperature of each of 764 wall tubes. Of these, 78 are connected to a recorder mounted on the boiler instrument panel which has been accepted by the operators as a real aid in operation.

The first reliable mercury detector depended on blowing samples of flue gas over selenium-sulphide coated paper, darkened by mercury, and scanning the paper with a photoelectric cell. This instrument can detect one ppm of mercury vapor. The latest mercury detector depends on the opacity of mercury vapor to ultra-violet light of a certain wave length. A photoelectric tube records the vapor concentration on a meter on the boiler panel. This detector will record 0.01 ppm of mercury vapor. The normal test consists of throwing one cubic centimeter of mercury into the fire which gives full-scale reading on the concentration meter.

Up to the time of the Lynn boiler, which had chrome-molybdenum-steel tubes, all previous mercury boilers were made of ordinary low-carbon steel, in most cases calorized by the dip method and heat treated. Sicromo 5S, a chrome-molybdenum-silicon steel, has been used for the Kearny boiler. It has the same 100,000-hr rupture strength at 1140 F as carbon steel has at 975 F. In the cooler passes of the fog bank, Croloy gives equal oxidation resistance.

Solubility of Iron

The solubility of iron in mercury at high temperature has been a fundamental obstacle in the development of the mercury cycle. This action reduced the thickness of metal and disintegrated iron and iron-oxide deposits in cooler regions of the boiler frequently restrict or stop the flow of liquid or vapor. The solubility of Sicromo 5S is only a fraction of that of carbon steel, with the possibility of extending cleaning periods by 20 times.

A parallel investigation indicated that zirconium and titanium inhibited solubility of steel, the latter being preferred because of its ease of application. The amount of titanium required is a function of temperature from 0.0001% for 850 F to 0.001% for 1000 F.

Steel surfaces, even though slightly oxidized, can be wetted by mercury alone with time and patience. But such surfaces will not remain wetted if more oxygen is introduced; mercury is a poor deoxidizing agent. The com-

(*Continued on page* 170)

Jointless Square-Tubular Busbars Improve Distribution Efficiency

Large Chicago manufacturing plant installs busbar system running to all departments of a six-story building. Bolted joints avoided by welding and brazing

By R B WOODRUFF
Air Reduction Sales Company

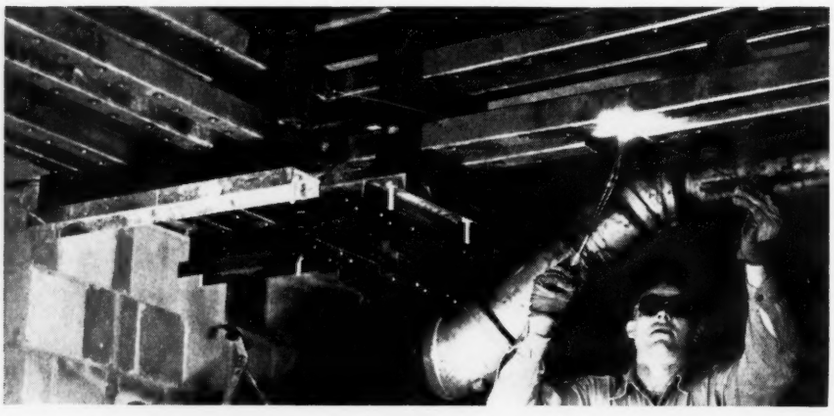


Fig. 1—Operator makes overhead brazed joint on one of the busbars

▶ UNTIL QUITE RECENTLY, low-voltage busbar structures were usually confined to the switchboard. From there, power was distributed in heavy-copper insulated cables run in conduits to distribution centers. In cases where large amounts of current are transmitted, these cable systems become cumbersome and the copper, because of skin effect, is not used at best efficiency.

To overcome these and other difficulties, modern busbar systems are sometimes run to all departments. This permits using efficient tubular conductors, which are welded or brazed together to eliminate all bolted joints, as in the in-

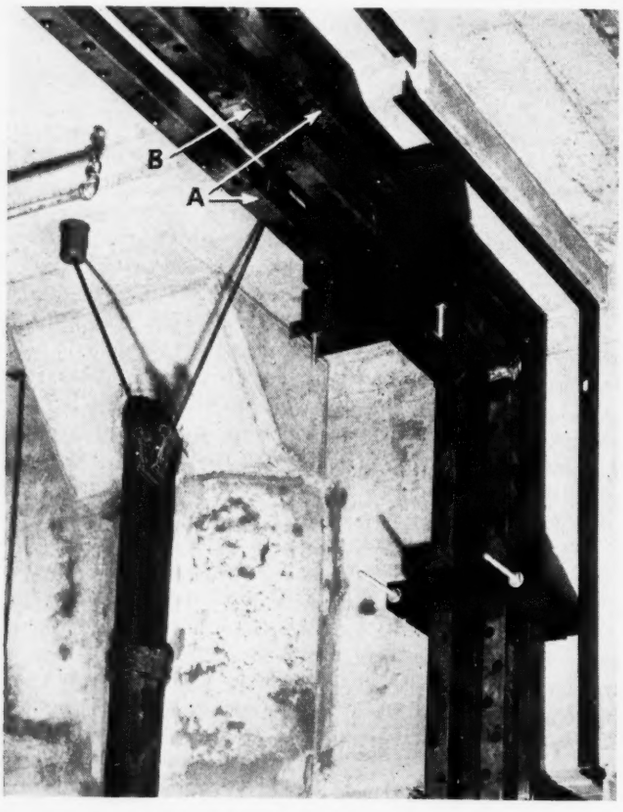


Fig. 2—Two right-angle joints make offset to carry busbars through desired location in tile wall

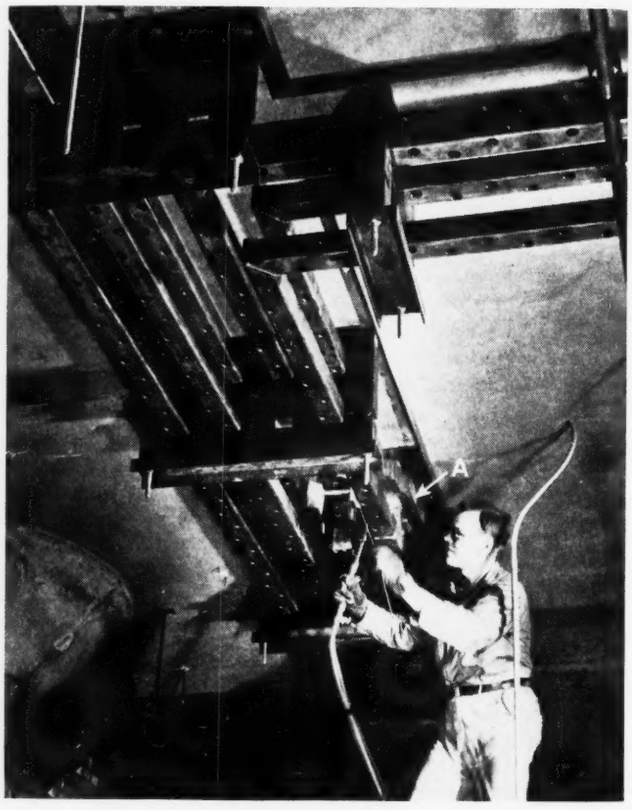


Fig. 3—Operator makes a brazed joint on one of the jumpers used to get around vertical risers

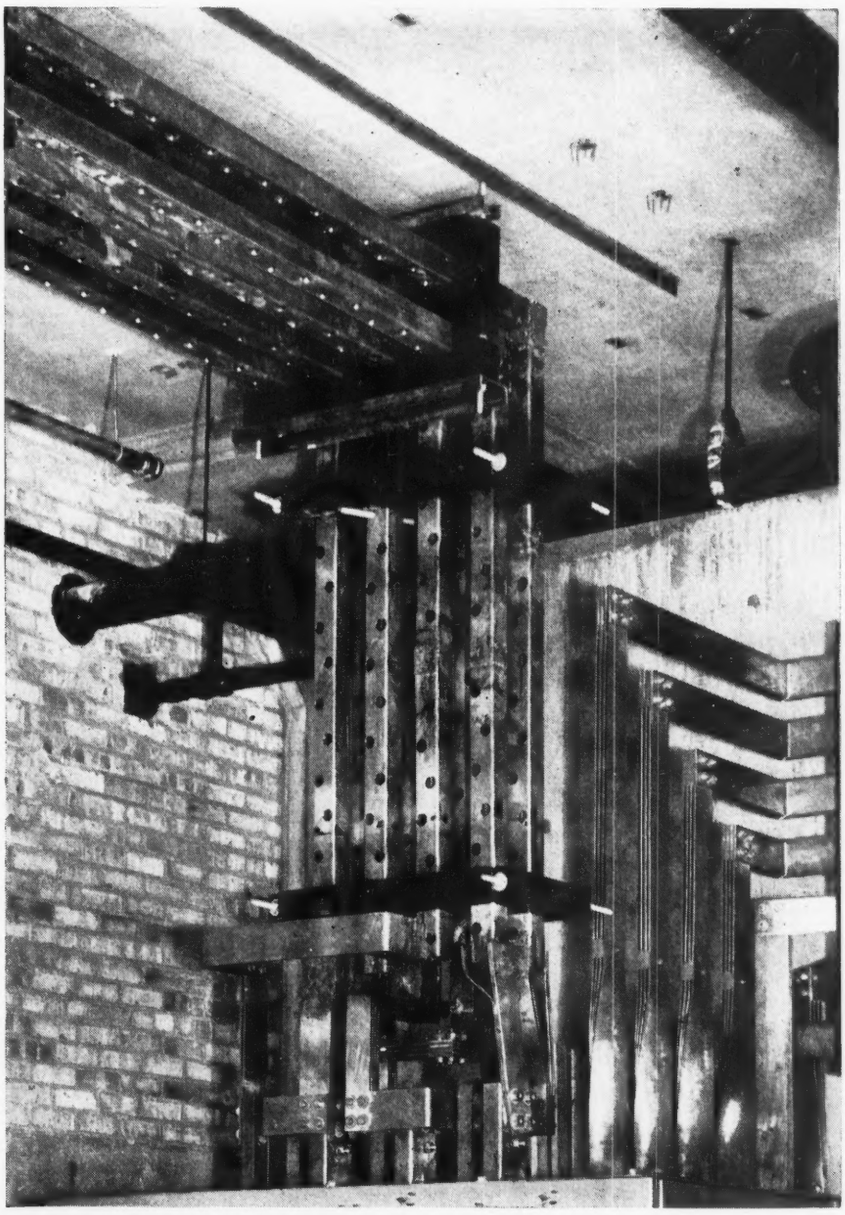


Fig. 4—Connections between busbars and switchboard were made by brazing connectors to the ends of the busbars and bolting them to the switchboard

stallation described on these pages.

One of the largest busbar systems attempted so far has just been put in the General Electric Co's new building in Chicago. Approximately 50,000 lb of ventilated square copper tubing was required on the installation, which runs through the entire six floors of the building.

Three bars, 3 in. square and ¼ in. wall thickness, carry the 208-volt, 1800-amp, 3-phase, 60-cycle current; another bar, serving as a neutral, is 3 in. square and ⅛-in. wall thickness. Right angles were prefabricated by mitering and carbon-arc welding at the Chase Brass & Copper Co's plant; straight line joints, jumpers, supports, etc, were brazed on the job.

Fig. 1 shows an operator making an overhead braze on one of the bars, using a torch with a 2-flame tip for heating. The bars are set in ebonite clamps, which were left loose. Final alignment of the bars was done by wedging. No tight clamps were used during the brazing operation, in order to permit free expansion and contraction of the copper bars. Thus, there was no bar distortion, and locked-up stresses were practically eliminated.

Cover plates were left off the ¼-in. wall bars and joints were straight butt-welded. On the ⅛-in. neutral bar, however, such plates were used. Fig. 2 shows the bars angled down to go through one of the tile walls. Brazed joints can be seen on the top sections at *A*, and the cover plates used on the neutral bar are visible on the lower

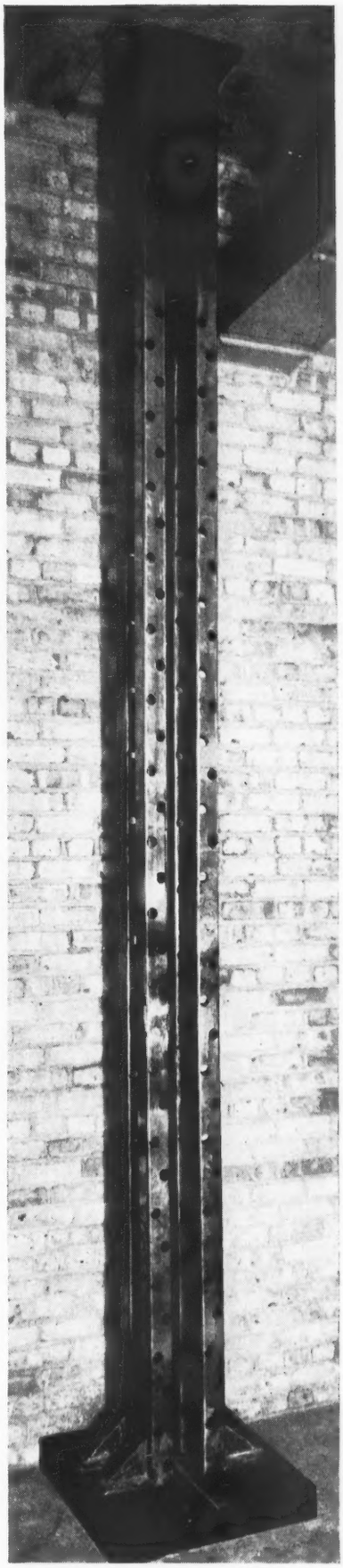


Fig. 5—Vertical busbars passing up from one floor to another are supported at the bottom on ebonite blocks by copper feet brazed to the square tubes

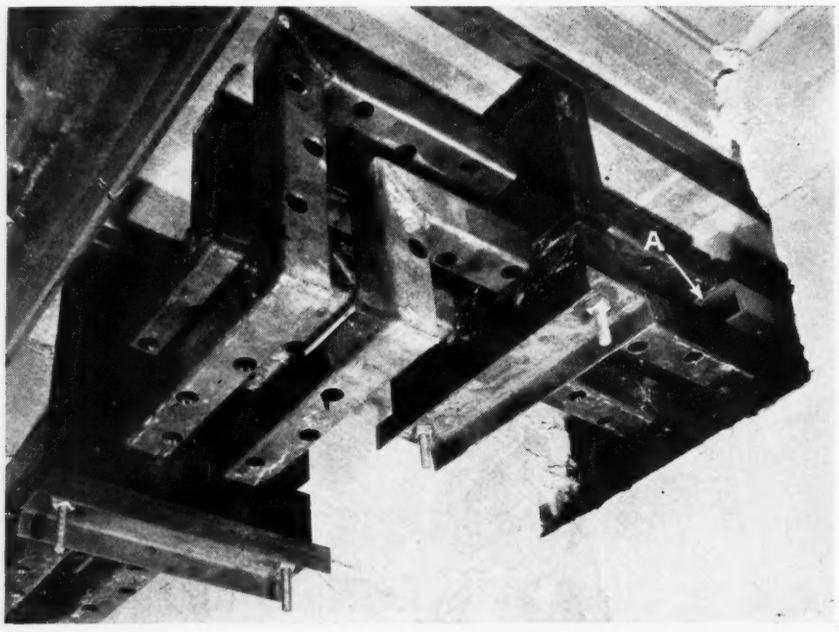


Fig. 6—Some of the intricate right-angle welded constructions required to run the busbars to the different departments in the building

right-hand bar, at *B* in the photograph.

In Fig. 3 the operator is making a braze joint on the jumpers used to get around the vertical risers. Jumpers are formed from two pieces of ¼ x 3-in. copper bar, about 10 in. long. One of the jumpers can be seen at *A*, in front of the operator's head. Clamps held the jumpers in alignment during brazing.

Fig. 5 illustrates the method of supporting the vertical bars passing up from one floor to the next. The supports at the bottom of the photo are ¼-in. by 3-in. copper bar, with a gusset of the same material brazed to the bus, resting on an ebonite base.

Some of the intricate fabricated bends necessary to run the busbars through the different rooms of the building are shown in Fig. 6. One of the really tough brazing jobs was encountered at this point (see opening in the wall at *A* where the joint had to be made). On the other side of the wall there is a small closet to house the switchboard for this floor, and there was barely room to put a ladder in to get at the joint. As mentioned previously, mitred corner joints are carbon-arc welded.

Switchboard Connections

At the lower right, Fig. 4, are shown the connectors brazed to the ends of the busbars and the switchboard connections bolted to the other end of the connectors. These bolted connections, the only ones in the system, are necessary to provide for quick removal or changes at switchboard or transformers.

This system takes care of all electrical requirements, such as light, current for motors, test blocks, etc. After the installation was finished, each bar received a coat of special paint, and then the entire assembly was encased in a transite enclosure. If necessary, blowers can be put in at the end of the transite enclosure to keep the bars cool.

✦ ✦ ✦

Steam-Pressure Regulation by Automatic Control

E S Bristol, engineering department, Leeds & Northrup Co, explains by hydraulic analogy the operation of automatic boiler controls and their limitations in regulating steam pressure

▶ THE STEAM-PRESSURE regulating element is the heart of any automatic boiler-control system, whether it be simple or elaborate. As in many other forms of automatic control, a simple hydraulic analogy can be used to illustrate the basic control action.

Fig. 2 represents such an analogy, with the various elements designated in terms of corresponding equivalents in an automatic boiler-control system. The left-hand tank represents a boiler drum with water stored in it. The boiler steam outlet is pictured by the lower pipe with an orifice equivalent to resistance to steam flow through the superheater and valves between the boiler drum and steam header, which is represented by the right-hand tank. In the line leaving the header is a turbine throttle valve or other means of varying steam demand on the boiler. A vertical slide gate controls fuel supply (represented by water flow) to the boiler.

The master controller is responsive to water level (steam pressure) in the header tank through float M_1, pivoted at M_2. The vertical link L transmits float motion to the upper lever pivoted at M_4 to move the fuel valve. Amount of valve motion for a given water-level change can be adjusted by changing the position of sliding block M_3 on the float lever. This elementary mechanism represents the essential features of the usual master combustion controller of the simple or non-pressure compensated type. Such a master controller would not act directly upon the fuel-control mechanism as shown, but would use suitable relay mechanisms to actuate both fuels and air controllers.

In the figure the control action is of the proportional-position type in which water level in the header tank, representing header steam pressure, takes a different value for each load demand. Thus, as the turbine throttle valve is opened to increase flow from the boiler

drum, header level (pressure) must drop to open the fuel valve to increase the combustion rate.

This dropping characteristic, as it is sometimes called, is well suited to the natural characteristic of the controlled system, since the header pressure must produce changes in flow from the boiler. By properly calibrating the controller mechanism, the initial level change in the header for a new flow to the turbine can be made to produce very nearly the required motion of the fuel valve to obtain the required new rate of supply. Under these conditions, boiler-drum pressure can be held practically constant despite variations in steam demand.

However, the header pressure change H can never be reduced to less than the amount of the pressure change between drum and header for an instantaneous load change. If the controller working range H is made too narrow, hunting or continuous oscillation will result. For stable regulation maximum range H must normally be made slightly greater than the pressure drop from drum to header at maximum flow. Pressure drop at the boiler drum releases some of the stored energy in the system and reduces the amount by which fuel supply must immediately be changed to meet a sudden increase in demand. Correspondingly, rise of drum pressure with decrease of load lessens the immediate decrease in fuel supply required to meet a sudden load drop.

Storage Effect of Drum

The energy storage provided by a boiler drum of appreciable size can thus be employed to cushion the effect of sudden load changes, if drum pressure is allowed to vary with load demand. Reduction in drum size on modern high-pressure boilers minimizes the extent of this possible cushioning effect and requires a control action capable of quickly and accurately proportioning combustion rate to load demand.

Fig. 3 shows a modified schematic system, with a supplementary adjustment for correcting header pressure to offset the variations permitted by proportional-position control action, Fig. 2. The additional element comprises a vertically movable support for pivot M_4. This mechanism requires the header pressure to change to move the fuel valve to the required position, as in Fig. 2. Following this action, however, pivot M_4 can be shifted manually to position the fuel valve to return the header pressure to a standard value.

To obtain this result it is necessary to shift the pivot so as to move the valve further in the same direction than it was moved by the control. Thus, if header pressure drops with a given increase in flow to the turbine, the fuel valve will open until the system balances at some lower header pressure with fuel inflow just equal to steam outflow to the turbine. Manual lowering of pivot M_4 will further open the fuel valve and increase inflow in excess of outflow, causing header pressure to rise and close the fuel valve until inflow again balances outflow. By noting the required positions of M_4 at various loads over the working range, it would be possible to make up a calibrated scale for M_4 showing, for any flow, its proper position to maintain a fixed header pressure.

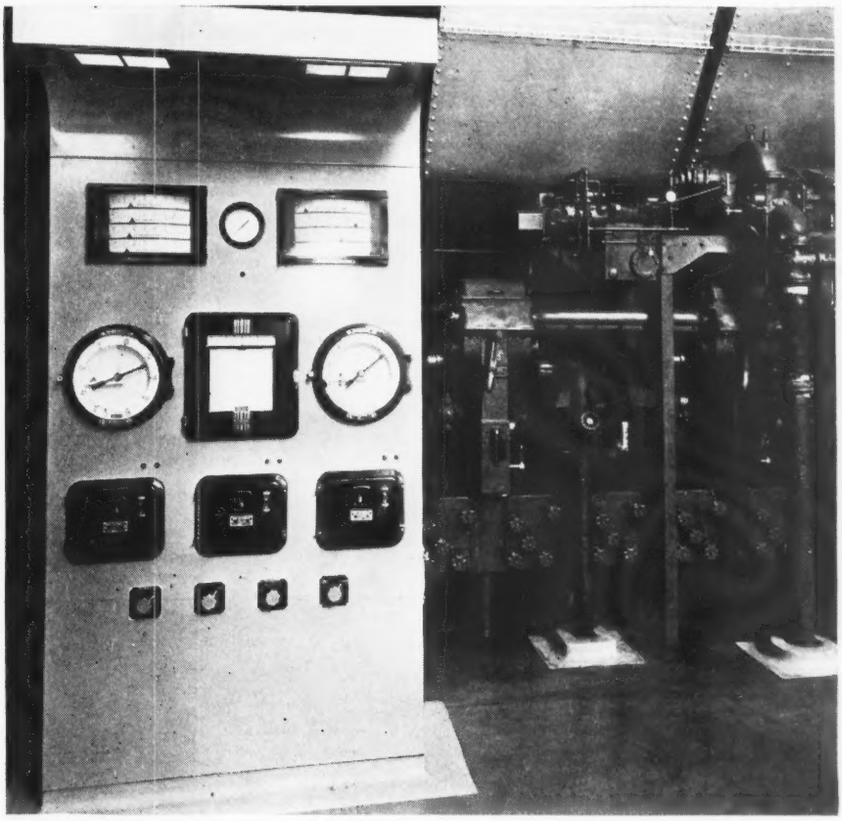


Fig. 1—On the panel at left are the metering and automatic combustion control equipment for operating a stoker-fired boiler under practical-test conditions

Pressure Adjustments

Readjusting the control transfers the pressure variations from the header back to the boiler drum. The difference in pressure between drum and header is fixed for any given flow. Thus, if pressure is held constant at either of the two points, it must vary at the other by the amount of line drop due to flow. When header pressure is returned to standard value following a load change, the required correction in boiler-drum pressure is accompanied by corresponding change of stored energy in the boiler drum. This type of control action can thus be considered as consisting of two components—one, an adjustment of fuel supply to balance a change in steam demand and, two, a temporary change in fuel supply continuing until boiler-drum pressure is returned to the desired value.

Fully automatic-control action, capable of returning the header pressure to a standard value, can be obtained by substituting suitable automatic means for the manual adjustment of pivot M_4, Fig. 3. The metal bellows M_5, shown in Fig. 4, schematically represents one way of accomplishing this result. Water-supply pressure (fuel pressure) as regulated by the fuel valve is definitely related to rate of water inflow and can be applied to bellows M_5 to position pivot M_4 according to rate of flow.

For example, if the control opens the fuel valve in response to an increased steam demand, fuel pressure will increase. This increase in fuel pressure will be transmitted to the bellows, which will expand and lower pivot point M_4 to open the fuel valve further and return header steam pressure to normal. With suitable calibration a readjustment can thus be introduced to return the header pressure always to the same value, no matter what the rate of flow happens to be.

An essential feature of the supple-

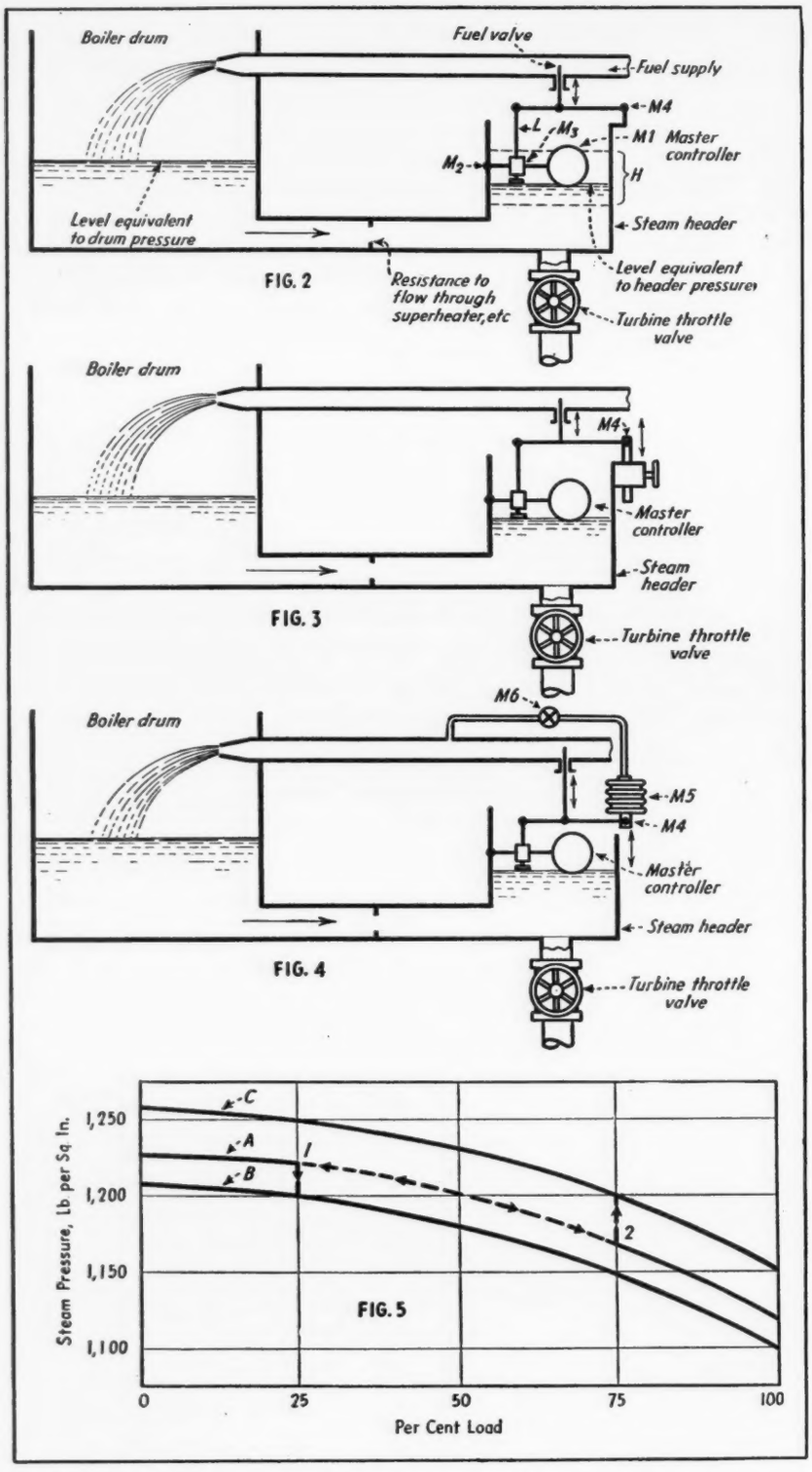


Fig. 2—Hydraulic analogy of boiler drum, steam header, master steam-pressure regulator and fuel supply. Fig. 3—Same as Fig. 2, but with manual compensation M_4 added to return steam pressure to a constant value. Fig. 4—Same as Fig. 2, but with automatic compensation for steam-pressure drop. Fig. 5—Curves show action of a steam-pressure compensated-master boiler controller

mentary action for producing return to standard header pressure is valve M_6, which must be set to retard the corrective action to a rate at which the pressure can actually be changed. With this valve too far open the automatic control will hunt or oscillate, because it is not possible to correct pressure instantaneously.

The controller, Fig. 4, differs from the master-control element of most boiler furnace-control systems in that the regulation is applied directly to fuel supply. Actual master controllers commonly vary air or other fluid loading pressure, which acts through a number of relay devices to vary fuel and air supplies. In such controllers the loading pressure would actuate the pressure-compensating element equivalent to bellows M_5.

Controller Action

Fig. 5 shows graphically the action of a pressure-compensated master controller. Curve *A* shows a typical relation of steam pressure to boiler-head pressure, for a master controller assumed to be operating in a plant where normal header pressure is 1200 lb per sq in. If the system is in balance at 50% load, header pressure will be held at normal value. With a change in load, primary action of the control will function in accordance with curve *A*, which follows the natural square law for pressure drop in the header. Master controllers are commonly designed to follow this square-law relation. Thus, it will be seen that header pressure at 50% load is 25 lb less than pressure at 0 load (1225 lb), while header pressure at 100% load (1125 lb) is 100 lb less than the no-load value.

If we assume a sudden load drop from 50 to 25%, pressure will rise to point 1, after which the compensating action of the controller will drop the pressure to 1200 lb. For a subsequent load change, the primary control would then follow curve *B*. On the other hand, if we assume the system to be in balance at 50% load as before and that the load suddenly increases to 75%, pressure would drop along curve *A* to point 2, after which the compensator would raise the pressure to 1200 lb. On the next load change the controller would then have a primary response along curve *C*. The effect of the compensator is therefore to shift the primary characteristic of the controller up or down so that it always intersects the normal pressure line at the point corresponding to the existing load.

Summary

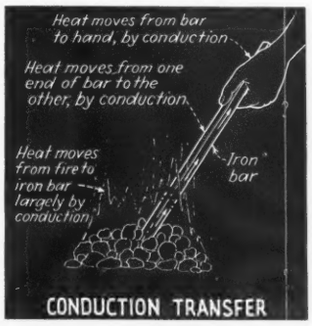
To summarize: A typical master controller for a boiler plant functions according to the natural characteristic of a boiler and header, whereby header pressure drops with increase in load because of resistance to flow through superheater, piping, etc. The header pressure change is instantaneous with change in flow and cannot be prevented by even an ideal controller. Compensation can be provided, however, to restore header pressure to normal after the initial response, at a rate which must be suited to the rate at which the boiler will respond to a changed heat input.

HEATING

By L N ROWLEY, *Associate Editor*

How Heat Behaves

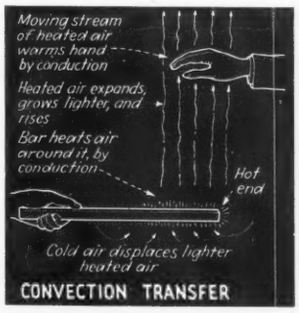
▶ WE RECOGNIZE THE PRESENCE of heat by a feeling of warmth; this quality of heat is measured by the familiar *Fahrenheit temperature scale. Intensity* of heat, or *hotness*, should never be confused with *amount* of heat. A red-hot buckshot is obviously *hotter* than a bucket of warm water, but there is greater *quantity* of heat in the water. We measure quantity of heat by *British thermal units*—1 Btu is the heat needed to raise 1 lb of water 1 F.


Heat moves from bar to hand, by conduction
Heat moves from one end of bar to the other, by conduction
Heat moves from fire to iron bar largely by conduction
Iron bar
CONDUCTION TRANSFER

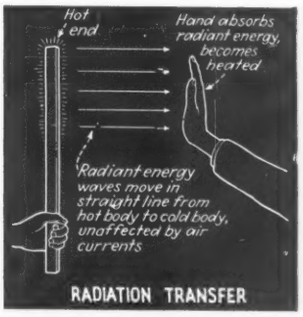
To raise the temperature of different materials requires different amounts of heat. For example, to raise 1 lb of plaster 1 deg F requires 0.2 Btu while it only takes half as much to raise 1 lb of copper 1 deg F. The amount of heat (measured in Btu) required to raise 1 lb of a material 1 deg F is called the *specific heat.*

Heat flows only to points of lower temperature. It flows in three different ways. *Conduction* is flow of heat from one body to another in direct contact with it, or from one part of a body to another part. The *rate* of flow is called *conductivity*. Materials that conduct heat poorly are *insulators.*

If a hot body is surrounded by air at a lower temperature, it will give up heat to the nearby air, by *conduction.* The heated air expands and becomes lighter. Heavier cold air displaces it. This fresh air also becomes heated and rises, and the cycle continues until all the air is at the same temperature. The moving stream of air set up by this process carries heat from one place to another, and so forms a distinct kind of heat transfer, called *convection.* Convection currents can be set up in any fluid. If a fan or pump moves the heated fluid, instead of natural action produced by temperature difference, we have *forced convection.*


Moving stream of heated air warms hand by conduction
Heated air expands, grows lighter, and rises
Bar heats air around it, by conduction
Hot end
Cold air displaces lighter heated air
CONVECTION TRANSFER

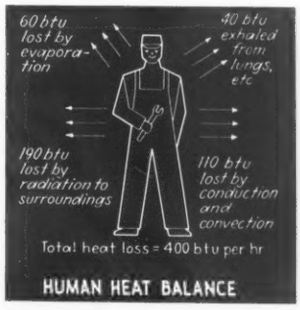
All substances throw off heat energy in the form of waves. This is known as *radiation* and forms the third method of heat transfer. *Intensity of radiation* depends on the temperature of the substance and its color, nature and surface condition. Radiant energy always flows from a hot body to a cold one; it flows in a straight line, unaffected by air currents; it can be focussed, absorbed or reflected, exactly as light rays. Solid bodies in the path of radiant energy waves absorb them and turn them into heat, the amount depending on the color, nature and surface condition of the solid body. A black body will absorb radiant energy readily; a polished metallic surface reflects radiant energy and is used as an insulator.


Hot end
Hand absorbs radiant energy, becomes heated
Radiant energy waves move in straight line from hot body to cold body, unaffected by air currents
RADIATION TRANSFER

The ability of materials to give out radiant energy is called *emissivity* and is expressed as the ratio of the given material's emissive power to that of a perfect black substance, taken as 1.0. The *reflectivity* of a substance is the percentage of radiant energy falling upon it which is reflected, and *absorptivity* is the fraction absorbed. *Absorptivity* and *emissivity* of a substance are numerically equal.

In simplest terms, heating involves maintaining a comfortable temperature inside a working space. However, no one temperature is comfortable under all conditions.

Research shows that the average human, under normal conditions, loses about 400 Btu per hr, partly by radiation to colder surroundings, by conduction to the cooler air and thence by convection, by evaporation of surface moisture (perspiration), in air exhaled from the lungs, and in body wastes. Comfort depends on maintaining this approximate total and a reasonable balance.


60 btu lost by evaporation
40 btu exhaled from lungs, etc
190 btu lost by radiation to surroundings
110 btu lost by conduction and convection
Total heat loss = 400 btu per hr
HUMAN HEAT BALANCE

For example, a workman at a bench close to a row of windows will lose more than the normal amount of heat by radiation from his body to the cold window surfaces. If the total heat loss is to stay the same, a higher than normal air temperature must be maintained so that the loss by convection will be less than normal. Tests on the reverse situation, in rooms with warm walls, floor and ceiling, show that even a lightly clothed and sitting occupant can be comfortable with air temperature down to 55 or 60 F.

More research is needed before this and other factors affecting comfort can be reduced to simple rules. In the meantime, most heating systems are designed on the basis of air temperature, although engineers should be aware of these other comfort factors.

How Buildings Lose Heat

▶ BUILDINGS LOSE HEAT in two general ways: (1) heat flows through walls and other exposed surfaces to the colder outside air, and (2) air leaks out of buildings through cracks around doors and windows, taking heat with it. Making the building more resistant to heat flow and cutting down air leakage reduces heating requirements; the resulting saving in the heating system must be balanced against the cost of improving the construction.

All three forms of heat transfer (conduction, radiation, convection) play a part in loss of heat through walls, so that a detailed analysis becomes complicated. However, the basic facts can be expressed in simple form, accurately enough for practical purposes.

Consider first a solid wall, say of brick. Heat flows from the inside to the wall surface by radiation from surrounding warmer objects and by conduction and convection from the room air. Through the wall itself, all heat flows by conduction. Radiation, convection and conduction all act to carry heat from the outside wall surface. At each of these three stages there must be a temperature drop if heat is to flow. This series of temperature drops is called the *temperature gradient* (see Fig. 1). These drops add up to the total difference between inside and outside air temperatures. How much temperature drop occurs at each stage depends on the relative resistances of the various stages; high resistance means big drop.

For simplicity, look first at the heat flow through the brick. Every material transmits heat, by conduction, at a rate peculiar to itself. Heavy dense materials transmit heat faster than lighter, less-dense materials. This property of a material is measured by k, the *coefficient of conductivity*. The k value for common brick is 5.0, which means that 5 Btu will pass through a 1-in. thickness of brick, 1 ft square, in 1 hr, for 1 deg difference in temperature. The heat flow through 8 in. of brick would of course, be much less, or 5 divided by 8 = 0.625. Here is the general rule: *for solid, uniform materials the rate of heat flow is given as k, for a 1-in. thickness; to get total rate of heat flow, divide k by thickness in inches.*

Surface Conductances

Let's look now at the heat flow from and to the wall surfaces. This is a much more complicated business than straight conduction through the wall, but for practical work the rate of flow is summed up in another coefficient, f, the *surface conductance*. This is the number of Btu transmitted in one hour from or to a surface 1 ft square, with a temperature difference between air and surface of 1 deg. Several factors affect the value of f: the rougher the surface the higher f will be; the greater the air movement past the surface the higher f will be. For practical work, the inside coefficient is taken as 1.65 and the outside as 6.0. Rougher exterior surfaces and higher rate of air movement account for higher outside coefficient.

Importance of surface conductance factors depends on the other resistances involved. Fig. 1 shows the temperature gradient through a single pane of glass and through a sheet of rigid insulation. The glass offers little or no resistance to heat flow and so the surface resistances become an important part of the total. The insulation is so highly resistant that the surface resistances play an unimportant part. An interesting point in connection with this difference is the much higher inside surface temperature of the insulation. This characteristic of all walls with high resistance to heat flow tends to reduce radiation from occupant's bodies to the walls and so makes for greater comfort.

For practical purposes, we need a single coefficient to express the over-all resistance of the wall, taking into account its actual thickness, the material involved, and the surface resistances. Such an over-all coefficient is called U and represents the number of Btu flowing through a square foot of a given wall construction in 1 hr, for 1 deg difference between inside and outside air temperatures. These over-all coefficients can be found by testing complete walls or by calculating from individual coefficients. For, example, the over-all coefficient for the brick wall of Fig. 1 would be:

$$\frac{1}{U} = \frac{1}{f_i} + \frac{x}{k} + \frac{1}{f_o}$$

where f_i is the inside surface conductance (1.65), f_o is the outside surface conductance (6.0), k is the conductivity of brick (5.0) and x is the thickness in inches (8). This works out to:

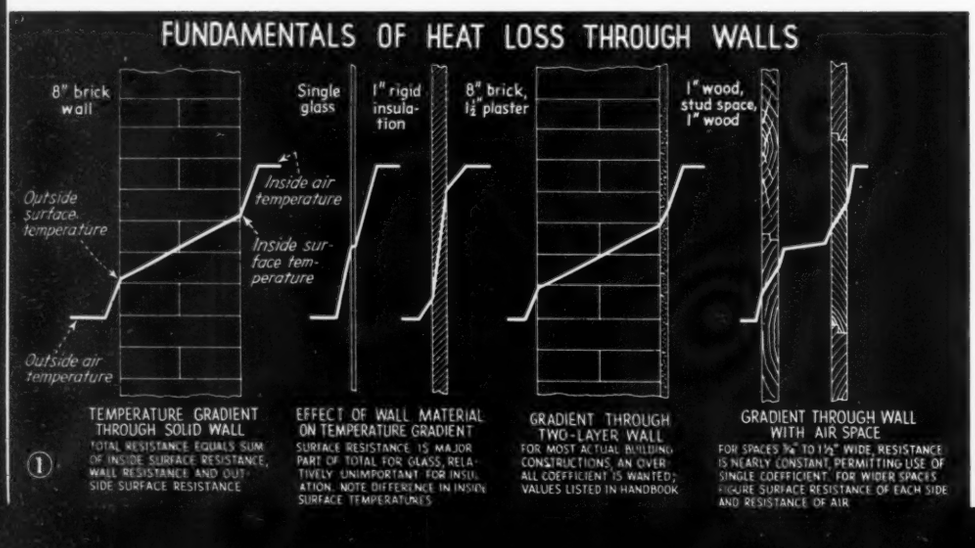
$$\frac{1}{U} = \frac{1}{1.65} + \frac{8}{5} + \frac{1}{6.0} = 0.98,$$

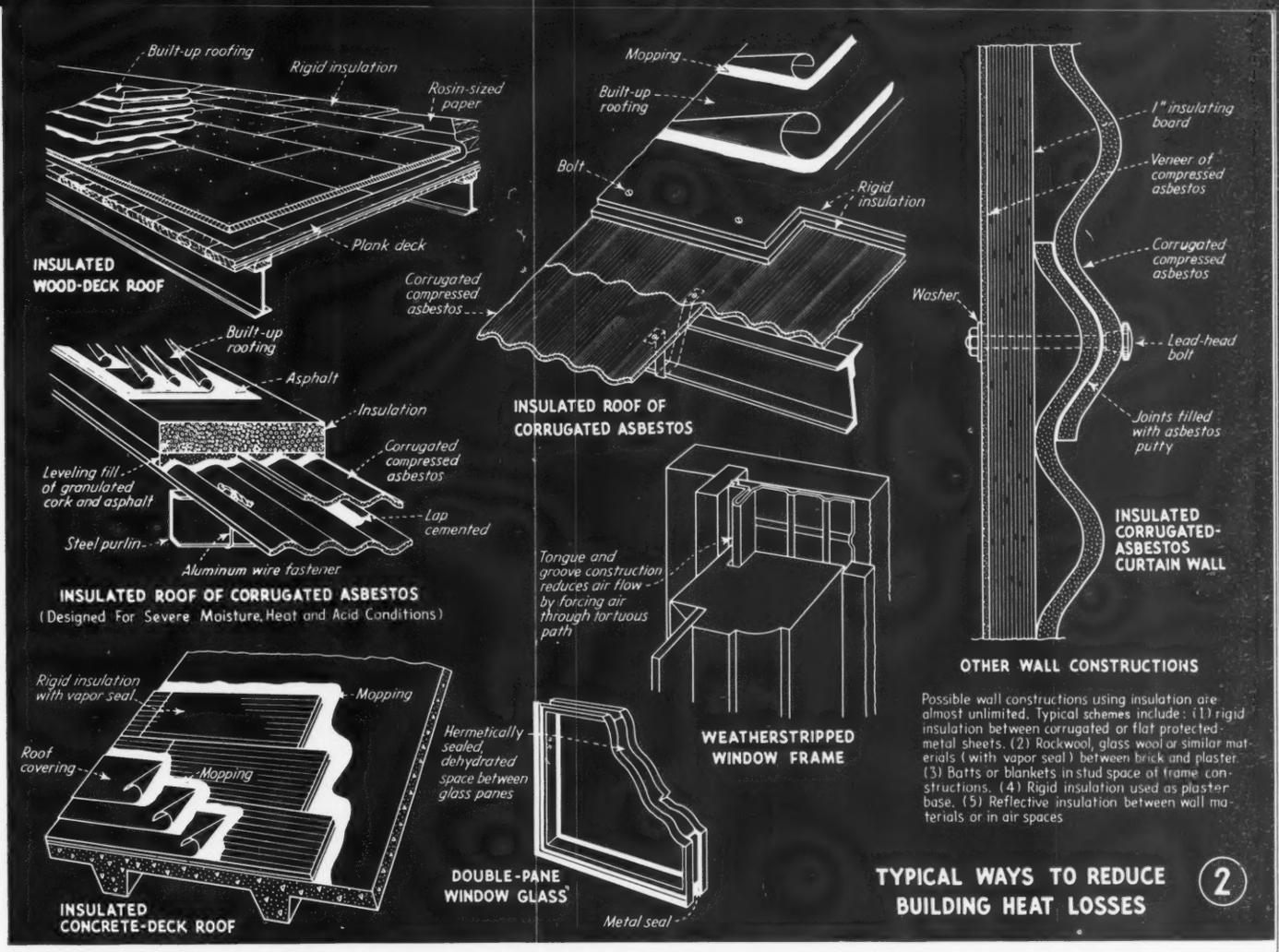
thus $U = 1.02$

Under actual conditions, few walls consist of a single material; most include several layers and many include air spaces. Fig 1 shows the temperature gradient through a typical brick and plaster wall. The over-all coefficient would be found in the same way as that above, with the exception of another $\frac{x}{k}$ for the plaster.

Heat flows across an air space by conduction through the air, by radiation from one wall to another and by convection currents that transfer heat from the high-temperature to low-temperature surface. There is always a certain amount of air movement even in theoretically "dead-air spaces." The actual combination of these heat movements is complex. Experimental work shows that, from about ¾ to 1.5 in., the conductance of an air space is more or less constant; below ¾ in., the conductance increases rapidly as the space gets narrower. For air spaces wider than 1.5 in., figure the surface conductance on each side of the space instead of using a single conductance value for the air space.

The ASHVE Guide, and other handbooks, give conductivity values for various materials, and over-all coefficients for common wall, floor, and roof constructions. Multiplying the over-all coefficient by the wall area involved and by the temperature difference between inside and outside will give the total heat loss. See page 76 for detailed


FUNDAMENTALS OF HEAT LOSS THROUGH WALLS
8" brick wall
Outside surface temperature
Outside air temperature
Inside air temperature
Inside surface temperature
Single glass
1" rigid insulation
8" brick, ½" plaster
1" wood, stud space, 1" wood
TEMPERATURE GRADIENT THROUGH SOLID WALL
TOTAL RESISTANCE EQUALS SUM OF INSIDE SURFACE RESISTANCE, WALL RESISTANCE AND OUTSIDE SURFACE RESISTANCE
EFFECT OF WALL MATERIAL ON TEMPERATURE GRADIENT
SURFACE RESISTANCE IS MAJOR PART OF TOTAL FOR GLASS, RELATIVELY UNIMPORTANT FOR INSULATION. NOTE DIFFERENCE IN INSIDE SURFACE TEMPERATURES
GRADIENT THROUGH TWO-LAYER WALL
FOR MOST ACTUAL BUILDING CONSTRUCTIONS, AN OVER-ALL COEFFICIENT IS WANTED; VALUES LISTED IN HANDBOOK
GRADIENT THROUGH WALL WITH AIR SPACE
FOR SPACES ¾" TO 1½" WIDE, RESISTANCE IS NEARLY CONSTANT, PERMITTING USE OF SINGLE COEFFICIENT. FOR WIDER SPACES FIGURE SURFACE RESISTANCE OF EACH SIDE AND RESISTANCE OF AIR
1


Built-up roofing
Rigid insulation
Rosin-sized paper
Plank deck
INSULATED WOOD-DECK ROOF
Built-up roofing
Asphalt
Insulation
Corrugated compressed asbestos
Leveling fill of granulated cork and asphalt
Lap cemented
Steel purlin
Aluminum wire fastener
INSULATED ROOF OF CORRUGATED ASBESTOS
(Designed For Severe Moisture, Heat and Acid Conditions)
Rigid insulation with vapor seal
Mopping
Roof covering
Mopping
INSULATED CONCRETE-DECK ROOF
Mopping
Built-up roofing
Bolt
Rigid insulation
Corrugated compressed asbestos
INSULATED ROOF OF CORRUGATED ASBESTOS
Tongue and groove construction reduces air flow by forcing air through tortuous path
WEATHERSTRIPPED WINDOW FRAME
Hermetically sealed, dehydrated space between glass panes
DOUBLE-PANE WINDOW GLASS
Metal seal
1" insulating board
Veneer of compressed asbestos
Corrugated compressed asbestos
Washer
Lead-head bolt
Joints filled with asbestos putty
INSULATED CORRUGATED-ASBESTOS CURTAIN WALL
OTHER WALL CONSTRUCTIONS
Possible wall constructions using insulation are almost unlimited. Typical schemes include: (1) rigid insulation between corrugated or flat protected-metal sheets. (2) Rockwool, glass wool or similar materials (with vapor seal) between brick and plaster. (3) Batts or blankets in stud space of frame constructions. (4) Rigid insulation used as plaster base. (5) Reflective insulation between wall materials or in air spaces
TYPICAL WAYS TO REDUCE BUILDING HEAT LOSSES
2

instructions on how to make heat loss calculations.

Heat loss through walls, floors, and roofs can be reduced by using suitable constructions. Usually this involves a class of materials known as *insulation* because of their high resistance to heat flow. Most insulating materials depend on extremely low conductivity for their effectiveness; this results from a structure containing innumerable tiny pores filled with non-circulating air. *Reflective insulations*, such as aluminum foil, feature low emissivity and high reflectivity, thus effectively stopping heat transfer by radiation.

Choice of insulation for any particular job depends on many factors, including insulating value, cost, ease of installation, chemical and physical stability, resistance to fire, vermin, etc.

In the past, factory, office, and commercial buildings were not usually insulated, because short hours of occupancy reduced the economic benefits. Recent developments in low-cost insulated constructions may change this situation markedly. As a general rule, greatest saving in total heat loss can be made by roof insulation. The illustration (2) shows typical methods. In modern office and factory building construction, where a high proportion of glass surface is provided for natural light, the greatest part of the wall loss is through the glass. Glass loss can be reduced by double windows (storm-sash) or by a double-pane construction fitted in a single sash. The air space between the two panes is dehydrated and hermetically sealed with a metal band. Where light is the only requirement, glass block may be used.

Infiltration Losses

When cold outside air displaces heated inside air, through leakage around doors and windows and other construction cracks, a substantial heat loss results. This movement of air results from wind pressure in most cases, but may also result from difference in temperature between outside and inside air.

Infiltration through properly built walls is negligible, particularly if interior surfaces are plastered with careful sealing at the baseboards. Most leakage occurs around door and window frames, between frame and wall, and through cracks between door and frame or sash and frame. Thorough caulking around frames will help to eliminate these cracks and cut the infiltration markedly. It is difficult to insure window tightness by ordinary construction, especially on wood sash. Good modern sash depends on weatherstripping of some sort for tightness. In double-hung sash this usually takes the form of a sliding tongue and groove; on doors and casement windows interlocking metal strips do the job. Weatherstripping of these two types cuts the leakage by forcing the air through a tortuous path having high resistance.

The rough-and-ready method of allowing infiltration in figuring heat loss involves assuming a certain number of air changes per hour, based on the general nature of the construction and the kind of occupancy, which affects opening and shutting of doors, etc. Multiplying the total building volume by the assumed number of changes per hour, gives the total volume of cold air to be heated up to room temperature.

A more refined method requires measuring the crack length of windows, doors, and other openings, and multiplying this by an appropriate value for the cubic ft of air per ft of crack per hr. These values have been determined experimentally for various types of door and window construction and for various wind velocities. However, wide differences in results are possible if windows are poorly fitted, shrunken or warped.

How to Figure Heat Loads

SELECTED HEAT TRANSMISSION COEFFICIENTS

Abstracted from Chapter 3, ASHVE Heating, Ventilating and Air Conditioning Guide, 1941. Reprinted by permission

TABLE 3. COEFFICIENTS OF TRANSMISSION (U) OF MASONRY WALLS

Coefficients are expressed in Btu per hour per square foot per degree Fahrenheit difference in temperature between the air on the two sides, and are based on a wind velocity of 15 mph.

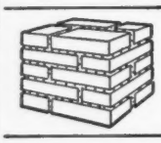
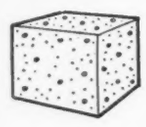
TYPICAL CONSTRUCTION	TYPE OF WALL	THICKNESS OF MASONRY (INCHES)	UNINSULATED WALLS				
			Plain walls—no interior finish	Plaster (½ in.) on walls	Plaster on wood lath—furred	Plaster (⅜ in.) on metal lath—furred	Plaster (½ in.) on plasterboard (⅝ in.)—furred
			A	B	C	D	E
	**Solid Brick** Based on 4-in. hard brick and the remainder common brick.	8	0.50	0.46	0.30	0.32	0.30
		12	0.36	0.34	0.24	0.25	0.24
		16	0.28	0.27	0.20	0.21	0.20
	**Concrete (Monolithic)** These figures may be used with sufficient accuracy for concrete walls with stucco exterior finish.	6	0.79	0.70	0.39	0.42	0.39
		10	0.62	0.57	0.34	0.37	0.34
		16	0.48	0.44	0.29	0.31	0.29
		20	0.41	0.39	0.27	0.28	0.27
	Cinder (Monolithic) Conductivity $k = 4.36$	6	0.46	0.43	0.29	0.30	0.29
		10	0.33	0.31	0.23	0.24	0.23
		16	0.22	0.22	0.17	0.18	0.17
		20	0.19	0.18	0.15	0.15	0.15
	Burned Clay aggregate (Monolithic) Conductivity $k = 3.96$	6	0.44	0.41	0.28	0.29	0.28
		10	0.30	0.29	0.22	0.23	0.22
		16	0.21	0.20	0.16	0.17	0.16
		20	0.17	0.17	0.14	0.14	0.14

TABLE 11. COEFFICIENTS OF TRANSMISSION (U) OF VARIOUS TYPES OF FLAT ROOFS COVERED WITH BUILT-UP ROOFING

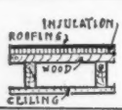
TYPICAL CONSTRUCTION WITH METAL LATH AND PLASTER CEILINGS	TYPE OF ROOF DECK	THICKNESS OF ROOF DECK (INCHES)	WITH METAL LATH AND PLASTER CEILINGS							
			No Insulation	Rigid Insulation (⅜ in.)	Rigid Insulation (1 in.)	Rigid Insulation (1½ in.)	Rigid Insulation (2 in.)	Corkboard (1 in.)	Corkboard (1½ in.)	Corkboard (2 in.)
			I	J	K	L	M	N	O	P
	Wood	1	0.32	0.21	0.16	0.13	0.11	0.15	0.12	0.10
	Wood	1½	0.26	0.19	0.15	0.12	0.10	0.14	0.11	0.095
	Wood	2	0.24	0.17	0.14	0.11	0.097	0.13	0.11	0.092
	Wood	4	0.18	0.14	0.12	0.10	0.087	0.11	0.096	0.082

TABLE 10. COEFFICIENTS OF TRANSMISSION (U) OF CONCRETE FLOORS ON GROUND

Coefficients are expressed in Btu per hour per square foot per degree Fahrenheit difference in temperature between the ground and the air over the floor, and are based on still air (no wind) conditions.

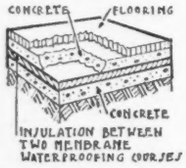
TYPICAL CONSTRUCTION	TYPE OF FINISH FLOORING				
	THICKNESS OF CONCRETE (INCHES)	No Flooring (Concrete Bare)	Yellow Pine Flooring on Wood Sleepers Resting on Concrete	Maple or Oak Flooring on Yellow Pine Sub-Flooring on Wood Sleepers Resting on Concrete	Tile or Terrazzo on Concrete
TYPE AND THICKNESS OF INSULATION		A	B	C	D
None	4	1.07	0.35	0.28	0.98
	6	0.90	0.33	0.27	0.84
	8	0.79	0.32	0.26	0.74
	10	0.70	0.30	0.25	0.66

TABLE 13. COEFFICIENTS OF TRANSMISSION (U) OF DOORS, WINDOWS, SKYLIGHTS AND GLASS WALLS

Coefficients are based on a wind velocity of 15 mph, and are expressed in Btu per hour per square foot per degree Fahrenheit difference in temperature between the air inside and outside of the door, window, skylight or wall

A. Windows and Skylights

DESCRIPTION	U
Single	1.13
Double	0.45
Triple	0.281

B. Solid Wood Doors

NOMINAL THICKNESS INCHES	ACTUAL THICKNESS INCHES	U EXPOSED DOOR	U WITH GLASS STORM DOOR
1½	1 9/16	0.52	0.35
1¾	1 13/16	0.51	0.35
2	1 5/8	0.46	0.32
2½	2 1/8	0.38	0.28

▶ FIGURING HEAT LOAD of a building is a relatively simple job but involves experienced judgment in choice of coefficients for certain conditions. The average engineer should known how the job is done so he can make rough calculations and check figures, but where actual design of a system for a new or existing building is involved, it is always advisable to put the matter in the hands of an experienced engineer.

There are two kinds of heat-loss calculations: those made to determine the maximum heat loss on which the size and layout of a heating system depend, and those made to determine the total heat loss for a season or part of a season, to check fuel consumption or estimate heating costs. Both start with measurement of wall, floor and roof surfaces, and determination of infiltration quantities. The same coefficients are allowed in both cases. The difference comes in when temperature difference is introduced: for design calculations, the likely maximum temperature difference is used, while for seasonal figures an average difference is used.

Typical Example

The procedure can be seen most clearly by following through a typical example. The floor plan on the next page shows the office and drafting room of the Super-Iron Foundry Co, of New York City, and lists the specifications.

To start figuring, tabulate the various surfaces through which heat will leak, using a form similar to that shown. Where the same temperature difference exists, total areas can be used, but walls, floors, etc, working against different temperature drops must be handled separately. Glass and walls leak heat at different rates; the easiest way to handle walls with windows is to figure the total window area first and then substract this from total wall area to get net area. Likewise doors must be figured separately and the total door area subtracted from wall area.

In the tabular form, infiltration is figured by measuring crack length, in linear ft. For a double-hung window, crack length is three times the width plus two times the height. In rooms with more than one exposed wall, the crack length for the wall having the most windows should be used, but in no case should less than half the total crack length be figured. In the drafting room of the example there are

three exposed walls; crack length of the side with most windows is less than half of the total for the room, so half the total is used.

Coefficients for the various sources of heat loss can be found in many handbooks but the figures in the ASHVE Guide are most complete and easy to use. Sample data from the Guide tables are reprinted on page 76; the engineer should consult the Guide for complete data and explanatory notes. The Guide tables give over-all coefficients for complete typical constructions. Where special constructions are encountered, the over-all coefficient can be figured by summing up the coefficients of the individual parts.

Effect of Wind Velocity

Coefficients given are based on an average wind velocity of 15 mph. For normal work, these figures are sufficiently accurate but where high wind velocities are encountered, special coefficients may be figured or the heat loss may be increased by an arbitrary "exposure factor", say, 15%.

The infiltration coefficient (0.69) is calculated as follows: in Table 2, *Infiltration Through Windows,* page 104 of the 1941 ASHVE Guide, the air leakage per ft of crack for well-fitted double-hung wood windows is given as 39.3 cu ft, for 15 mph wind velocity. This figure can be converted into Btu per hr per ft of crack length by multiplying by 0.018, which in this case gives 0.69. The wind velocity used in figuring infiltration is usually taken as the average during the year's three coldest months (17 mph for N. Y. City).

To figure maximum heat load, the outside temperature is usually taken as 10–15 F above the lowest recorded temperature for the locality. Extremely low temperatures occur only for short intervals and there is usually enough heat storage in the structure and spare capacity in the system to handle such extremes if design is based on a slightly higher temperature. Ground temperature under a building may be taken as 45–50 F. For walls between two parts of a building where different temperatures prevail, the actual difference should be used.

Inside temperature to be maintained depends on the nature of the occupancy. It is taken as 70 F for office and drafting room, 55 F for foundry.

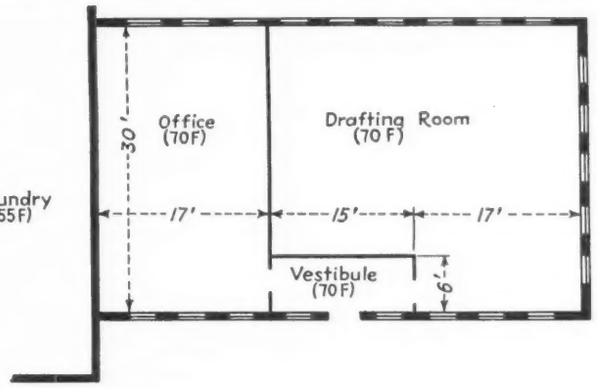
To get the total heat loss, multiply the net area or crack length for each part of the structure by the appropriate coefficient and by the temperature difference. The tabular form makes this a simple process and gives totals for each room as well as for the entire building. The grand total fixes the over-all capacity of the heating system and the individual space figures fix the distribution of heat.

Where large numbers of persons congregate, as in theatres, where heavy lighting loads exist, as in department stores, or where heat may be given off by furnaces or other industrial equipment, the sum of these heat supplies should be calculated. If this heat is available at all times while the building is occupied, it may be subtracted from the total requirements. However, the heating system, unaided, must be big enough to keep inside temperature well above freezing.

Infiltration may be figured in an easy but probably less accurate way by assuming that the volume of air in the building changes a certain number of times each hour and that the total amount of air must be heated from 0 to 70 F. For this case, one air change per hour might be a reasonable figure. The total volume is 30 x 49 x 10 = 14,700 cu ft. Multiplied by 0.018 and by 70-F temperature difference, we get approximately 18,500 Btu per hr infiltration loss, about 50% more than by the crack-length method.

To figure heat loss for a season, or for part of a season, we must substitute *average* temperature differences for the *maximum* figure used before. Weather Bureau reports give daily and monthly averages for many localities. If an average figure is used in the temperature difference column of the tabulation below, the *average heat loss per hr* will result. Multiplying this figure by the number of hours of heating in the period in question will give the total heat loss for the period in Btu. Strictly speaking, the average temperature for the hours of the day the heating plant is in operation should be used, rather than the Weather Bureau's 24-hr. average, but this method is accurate enough for most purposes.

The number of *degree-days* per day is the difference between 65 F and the daily mean temperature when the latter is less than 65 F. This is the so-called 65-F base, which is in common use. The idea behind the degree-day system is simple: experience shows that the heat loss from a building maintained at 70 F varies with the number of degrees difference between the average outside temperature and 65 F. Degree-day data for each month and each heating season are regularly published; the Degree-Day Handbook (Industrial Press, New York) includes comprehensive data for all parts of the United States.



CONSTRUCTION

Walls: 12"brick, ½"plaster
Windows: Wood, double hung, 3'X6'
Roof: 2"wood deck, ½"rigid insulation, plaster ceiling, 10'high
Floor: 8"concrete with oak flooring on pine subfloor, on sleepers
Door: 3'x6', solid wood, 2"nominal

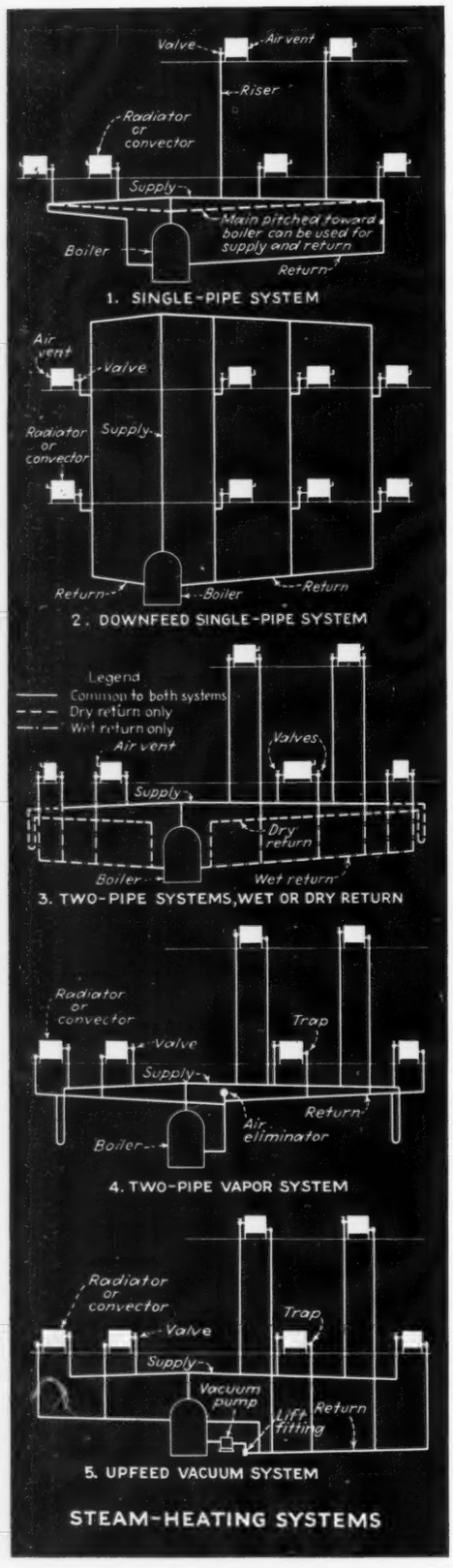
GENERAL DATA

Location: New York City
Design temp: 0 F
Average wind velocity: 17 mph
Average temp: 43.6 F during heating season
Daily heating hours: 12
Working days in htg season: 180

Space	Source of Heat Loss	Net Area or Crack	Coeff	Temp Diff	Heat Loss, Btu per Hr	Total Heat Loss	Avg Temp Diff	Avg Heat Loss	Total Avg Heat Loss
Vestibule	Walls	93	0.34	70	2,213	(Btu per hr)	44	1,391	(Btu per hr)
	Glass	36	1.13	70	2,848		44	1,790	
	Infiltration	63	0.69†	70	3,043		44	1,913	
	Roof	90	0.17	70	1,071		44	673	
	Floor	90	0.26	25*	585		25*	585	
	Door	21	0.46	70	676	10,436	44	425	6,777
Drafting Rm	Walls	538	0.34	70	12,804		44	8,048	
	Glass	252	1.13	70	19,933		44	12,529	
	Infiltration	147**	0.69†	70	7,100		44	4,462	
	Roof	870	0.17	70	10,353		44	6,508	
	Floor	870	0.26	25*	5,655	55,845	25*	5,655	37,202
Office	Walls(outside)	232	0.34	70	5,522		44	3,471	
	Wall(foundry)	300	0.34	15***	1,530		15	1,530	
	Glass	108	1.13	70	8,543		44	5,370	
	Infiltration	63**	0.69†	70	3,043		44	1,913	
	Roof	510	0.17	70	6,069		44	3,815	
	Floor	510	0.26	25*	3,315	28,022	25*	3,315	19,414
						94,303			63,393

† 0.018 X 39.3 = 0.69 * Ground temp taken as 45F
** Half total crack length *** 70-55 = 15F Total heat loss for season = 63,393 X 180 X 12 = 136,918,880 Btu

Heating Systems



THE BASIC MEDIUMS for heating are steam, hot water and warm air. Steam or hot water is nearly always generated at a central point and distributed through piping to heating surfaces in the various parts of the space to be heated. The surfaces transfer heat to the room by combined radiation and convection. After the steam or hot water has given up heat it flows back to the boiler for reheating.

Properly speaking, warm-air systems are those which transfer heat from a central source to various parts of a building by means of heated air moving in ducts. A furnace can be used to heat air directly but it is more common in larger buildings to heat the air by steam coils or, possibly, by hot-water coils. Systems in which steam or hot water is piped to local heating surfaces equipped with a fan give the positive air circulation characteristic of warm-air systems.

For each general system of heating, certain advantages are claimed. Steam gives up a large amount of heat by condensation so that only a comparatively small amount needs to be circulated (about 1/50 by weight or 1/30 by volume compared to hot water). High temperature, and thus better heat transfer, permits smaller heating surfaces. Positive circulation is insured, without pumps, by the pressure of the steam itself. These features of steam make systems flexible and relatively cheap to install.

Ease of control is the chief advantage of hot-water heating. The amount of heat given off by a hot-water heating surface depends on the temperature difference between room air and hot water. Varying water temperature or quantity gives easy control.

Warm-air heating systems, as used in large buildings, offer positive air circulation and ventilation. Provision may be made for filtering, humidifying or otherwise treating the air. Warm-air heating is a natural complement of summer air conditioning; the same distribution system will take care of both.

Steam Systems

1-Pipe System: Diagram (1) at left shows the simplest of steam systems, a 1-pipe upfeed hookup. Steam enters the radiator and condensation leaves it by the single connection. In the simplest of 1-pipe systems, the *mains* in the basement are pitched toward the boiler and condensation flows through them in the opposite direction to the supply steam. This is shown by dotted lines in the diagram. Interference between steam and water in the mains is eliminated by providing a separate return line to carry condensation from the *risers* to the boiler. *Air valves* or *vent valves* mounted on the radiator are designed to permit air to escape but not steam.

Another form of 1-pipe system features downfeed or overhead distribution. This is preferred for larger buildings of four stories or more because steam and water flow in the same direction in the risers, permitting smaller sizes to be used without interference with flow.

2-Pipe System: This has two connections at each radiator and separate piping for returns. In most cases, the return header runs below the boiler water level, as shown by dot-dash lines in (3) at left. In this wet-return hookup, a water seal at the lower end of each connection prevents steam flowing into radiators through return connections. This sometimes happens in a dry-return system, as shown by dash lines in the diagram.

Separating flow of steam and condensate permits handling larger quantities without excessive pipe sizes, making 2-pipe systems more suitable for large systems than the simpler and cheaper 1-pipe system. 2-pipe hookups can be arranged for downfeed as well as upfeed. Air is removed from the system by individual vent valves on the radiators.

Vapor System: Forcing air out of a radiator through a small vent-valve orifice requires considerable pressure; a thermostatic trap at the radiator outlet permits venting air through a much larger opening. Air is removed at a central point by an *air eliminator*. A system constructed in this way can operate at low pressure, less than 1 lb above atmospheric, and hence is called a *vapor system*. Throttling the supply valve will partially fill the radiator thus giving a simple means of controlling heat output. Other advantages of the vapor system are better air removal with faster heat-up, more even heating, and economy of operation; (4), at left, shows a vapor system.

A 1-pipe system can be equipped with special air valves (called vacuum valves) which provide quick venting and which prevent ready return of air. Pipe is sized to permit operation at a

few ounces pressure; the hookup is the same as that in (1).

Mechanical Return: In a system without traps, original steam pressure will return condensate to the boiler provided the lowest heating surface is far enough above boiler water level to provide static head to overcome the system pressure drop. This is a *gravity system.* In vapor systems where traps are used, steam pressure cannot help out on the return side and the static head must be enough to overcome both pressure drop and boiler pressure.

In large buildings, it is frequently difficult to arrange for gravity return and the common solution lies in draining condensate by gravity to a receiver located at a low point and lifting the condensate from receiver to boiler by either a *return trap* or a *condensation pump.*

Vacuum System: Use of a pump to pull air and condensation through the return lines characterizes the *vacuum system.* The pump maintains a vacuum on the return side, giving a greater pressure differential through the system, and thus insuring faster filling of the radiators.

In the *sub-atmospheric system,* steam supply pressure is reduced to produce a vacuum in the radiator. Changing the degree of vacuum changes the steam temperature in the radiator and thus its heat emission. Thus room temperature can be controlled by regulating supply pressure. In such a system, atmospheric pressure or higher only exists in extremely cold weather.

Hot-Water Systems

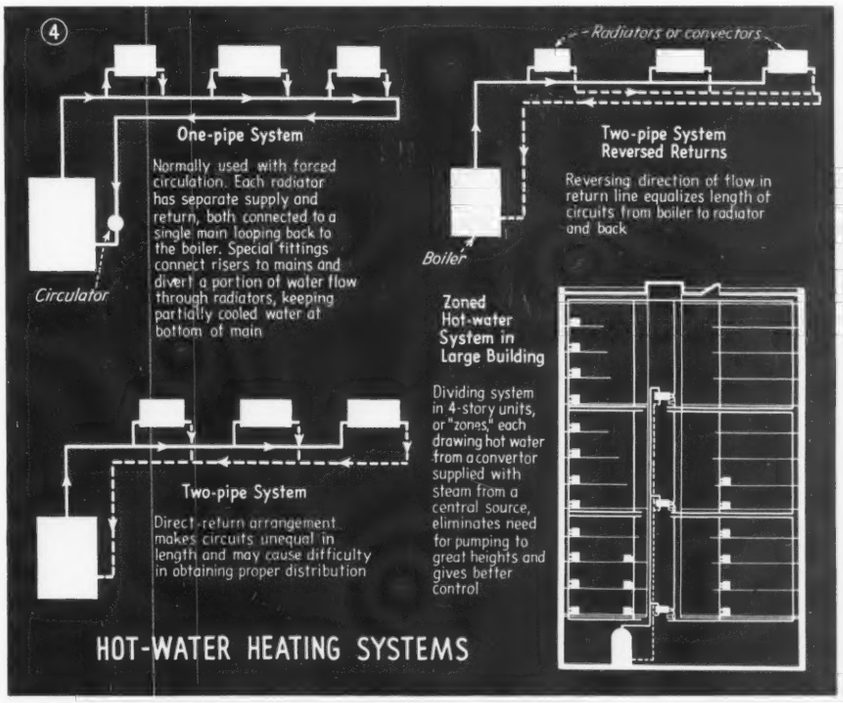
Hot-water systems are much simpler than steam because they handle only a liquid, not a vapor and a liquid. *Gravity* or *natural-circulation* systems depend on the difference in weight of hot and cold water to produce flow. This force is quite small and large pipes must be used to reduce pressure drop.

Forced-circulation systems, now widely used, employ a small pump to circulate the water, thus permitting smaller pipe sizes and reducing first cost. Against this saving must be balanced the somewhat greater operating expense introduced by the pump. With forced circulation, higher pressure can be carried in the system, which means that water temperature can be increased. Higher water temperatures increase heat emission from radiators, allowing them to be smaller for the same capacity. This, in turn, decreases first cost. Such systems have been designed for maximum water temperatures of 240 F but 180 F is more common.

Hot water for a system may be generated in a direct-fired heater, commonly called a boiler, or it can be generated indirectly in a convertor, a heat exchanger supplied with steam from another source.

1-Pipe System: Simplest and cheapest of all hot-water piping arrangements is the so-called *1-pipe.* Actually each radiator has a supply and a return connection with separate risers, but both connect into a single main which makes a loop back to the boiler. Special fittings connect risers and main and divert a portion of the water flow through the radiator. Successive radiators receive slightly cooler water due to partial mixing of returns from preceding radiators with supply water.

With a small circulator placed in the circuit just before the water enters the heater, this 1-pipe system has come into wide use recently for small buildings.


4
Radiators or convectors
One-pipe System
Normally used with forced circulation. Each radiator has separate supply and return, both connected to a single main looping back to the boiler. Special fittings connect risers to mains and divert a portion of water flow through radiators, keeping partially cooled water at bottom of main
Circulator
Two-pipe System Reversed Returns
Reversing direction of flow in return line equalizes length of circuits from boiler to radiator and back
Boiler
Zoned Hot-water System in Large Building
Dividing system in 4-story units, or "zones," each drawing hot water from a convertor supplied with steam from a central source, eliminates need for pumping to great heights and gives better control
Two-pipe System
Direct-return arrangement makes circuits unequal in length and may cause difficulty in obtaining proper distribution
HOT-WATER HEATING SYSTEMS

2-Pipe System: In a 2-pipe system, water flows from supply main to the radiator and back into a separate return main which connects back to the boiler. In a *2-pipe reversed-return system,* direction of flow in the return main is opposite to that in a normal system. This tends to equalize the length of the circuits and so to equalize flow. In large buildings, downfeed is customary, either with forced or natural circulation.

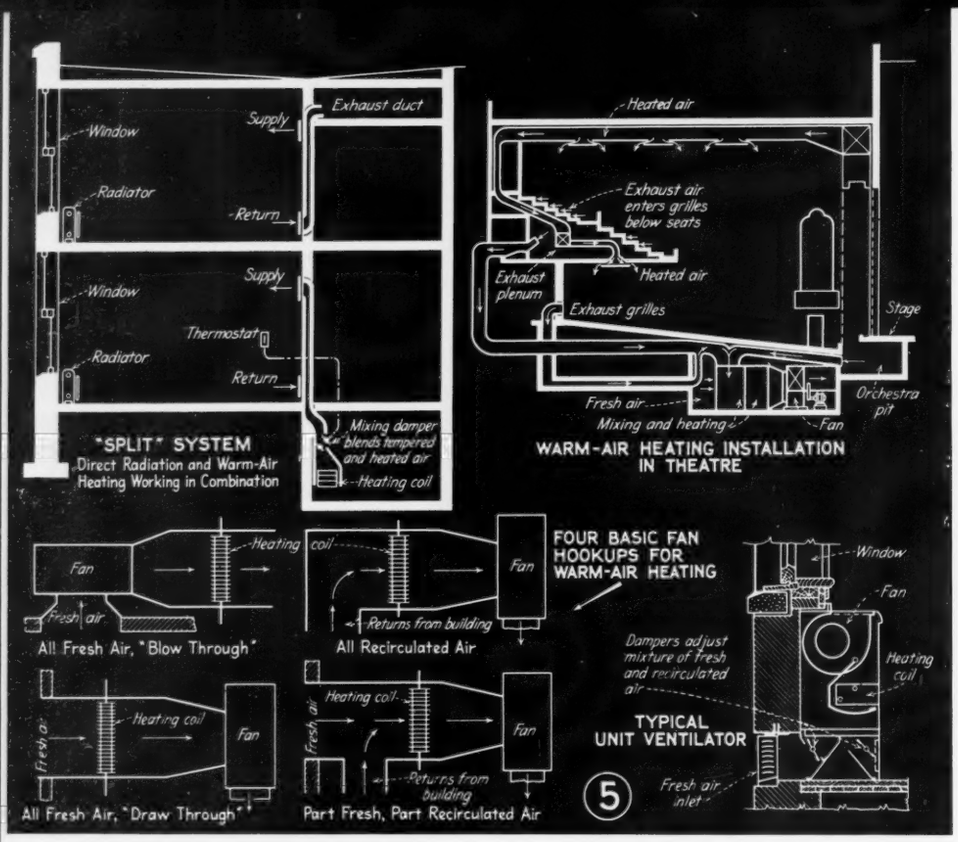
Closed and Open Systems: In any hot-water system, some means must be provided to take care of changes in water volume with change in temperature. An *expansion tank* usually does this job; in forced-circulation systems it is located close to the pump on the suction side, in gravity systems it is connected to the flow riser. Tank elevation must provide sufficient pressure on the highest radiator to keep water from boiling at maximum temperature; care must be taken to prevent freezing of tank or connecting piping.

Replacing the open expansion tank with a closed vessel partly filled with air and water permits location at lower levels. A *closed system* of this kind permits higher water pressures and thus higher temperatures and smaller radiators. A pressure-reducing valve and a relief valve in series between outside water supply and the heater will automatically keep the system full; the reducing valve will admit water when needed and the relief valve will bleed off the excess.

Large Installations: In tall buildings the pressure required to pump water to upper stories becomes excessive and it is customary to divide such systems into several parts. Steam from a central source flows to each section under its own pressure. A convertor supplies each section with hot water. Similar steam transmission lines with "substations" for hot-water generation serve large groups of buildings or even single buildings of considerable area.

Warm-Air Systems

Ventilation is a basic requirement in buildings where large numbers of people gather; positive circulation of air is also desirable in large spaces. These



call for some form of forced air distribution and since cold air can't be introduced into heated rooms, at least a minimum of heating is required. Central warm air systems can thus be divided into three types: (1) those in which radiators take care of the heat losses and air warmed to room temperature is circulated for ventilation, (2) those in which radiators and heated air divide the heating load, and (3) those in which high-temperature air takes care of all requirements.

Where ventilation is a prime requirement, all air may be taken from outside, heated, circulated, and wasted back to the atmosphere. Where ventilation requirements are not so strict, part of the air may be returned through exhaust ducts and mixed with fresh air before heating. In some cases where maximum economy is desired and natural infiltration supplies some fresh air, no outside air may be supplied to the heater, all air being recirculated.

Unit ventilators of the type shown are supplied with steam or hot water from a central point and so form part of a steam or hot-water system. At the same time they take in fresh air from outside and supply it, heated, to the space, in the same manner as a central warm-air system.

For central warm-air heating, numerous duct arrangements are employed to give flexible distribution and adequate control. A simple system, often called *hot-blast heating*, is particularly suitable for factories where close temperature control is not important and where forced ventilation is desired. A central heater supplies air at constant temperature through long trunk ducts fitted with outlets supplying the space.

A somewhat more refined system is illustrated in Fig. 5. Fresh and recirculated air enters a heating and filtering unit which forces air through distributing ducts to the occupied space. From there air is returned to the unit.

Often provision must be made for individual control of air temperature in a number of separate rooms. One arrangement to do this job is illustrated, Fig. 5.

Modern Heating Equipment

▶ STEAM AND HOT-WATER HEATING SURFACES are commonly called radiators, although all transfer heat by both radiation and convection. The term *convector* is applied to units delivering heat largely by convection.

Modern radiators are smaller and less conspicuous than older styles. Most are made of cast-iron, in sections joined by nipples. Fig. 7 shows three types: a free-standing unit with special flat front to increase radiant surface, a long wall-hung unit; and a radiator designed to be recessed. This latter is fitted for passage of air over a convection unit behind the radiant front.

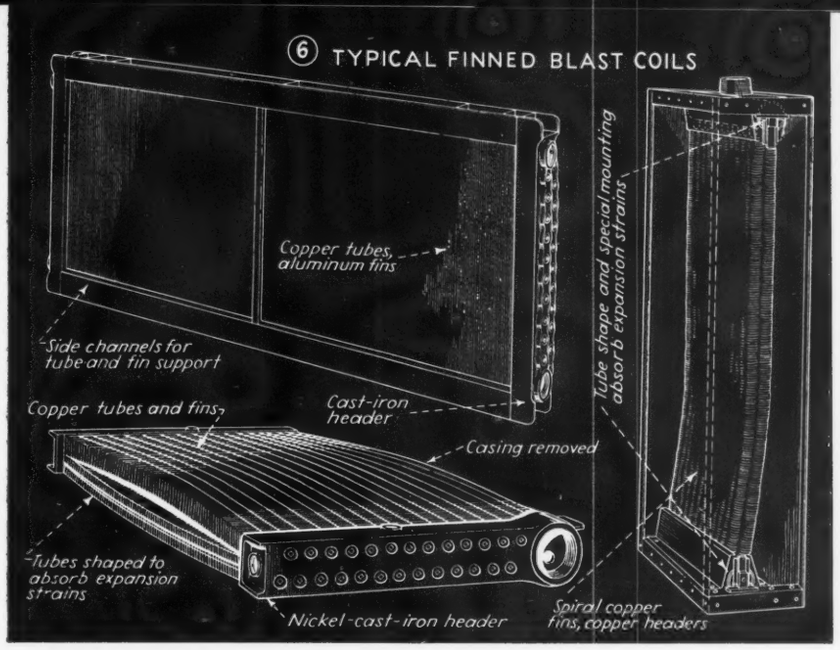
The illustration also shows typical convectors; one designed to be built into the wall with only the inlet and outlet grilles exposed and the other built into a cabinet for installation in the manner of a free-standing radiator. The heating elements in convectors are usually non-ferrous and finned. Output of convectors may be controlled by regulating supply of heating medium or by a damper which cuts down the amount of air passing over the surface.

Steam radiators are rated in *sq ft of equivalent direct radiation*, an equivalent sq ft being the amount of surface which will emit 240 Btu per hr with 215 F steam temperature and 70 F air temperature. For the pipe coils commonly used in industrial buildings, the heat emission depends on the pipe size and arrangement; for a 6-row coil of 1-in. pipe, the heat emission is about 570 Btu per lineal ft of coil per hr.

The cold surfaces of windows and exterior walls tend to cause cool currents of air moving downward to the floor; placing radiators on the outside walls, and particularly under windows, tends to counteract this effect. Free-standing radiators are often covered, for appearance, with enclosures of one kind or another; the general effect is to lower the heat emission, although with proper design this can be minimized and over-all comfort may be increased by using the enclosure to direct the current of warm air out into the room instead of to the ceiling.

With or without an enclosure, the heat emission will be increased by placing a sheet of aluminum foil or other reflective surface behind the radiator to throw back radiant heat that would otherwise be obsorbed by the wall. Flat paints, in dark colors, tend to increase the heat emission slightly, but radiators painted with aluminum or bronze paint will emit 6–7% less heat than units with bare surfaces.

Heating surfaces for warm-air systems are commonly called *blast coils;* common types include pipe coils, cast-iron sectional coils and finned nonferrous units which are lighter and more compact for a given capacity. Fig. 6 shows several finned-tube units.


⑥ TYPICAL FINNED BLAST COILS
Copper tubes, aluminum fins
Side channels for tube and fin support
Copper tubes and fins
Cast-iron header
Casing removed
Tube shape and special mounting absorb expansion strains
Tubes shaped to absorb expansion strains
Nickel-cast-iron header
Spiral copper fins, copper headers

Final temperature of air leaving a blast coil depends on the number of rows of tubes and air velocity. Rating tables give final temperature and condensation in lb per hr for various face velocities, tube rows, and entering air temperatures. First step requires assuming a face velocity suitable for the conditions (400 to 800 fpm); the rating tables then tell how many tube rows will be needed for the desired final temperature. Dividing cfm to be handled by face velocity gives the required net face area of the coil, and knowing area and tube rows, a suitable coil can be selected.

Unit Heaters

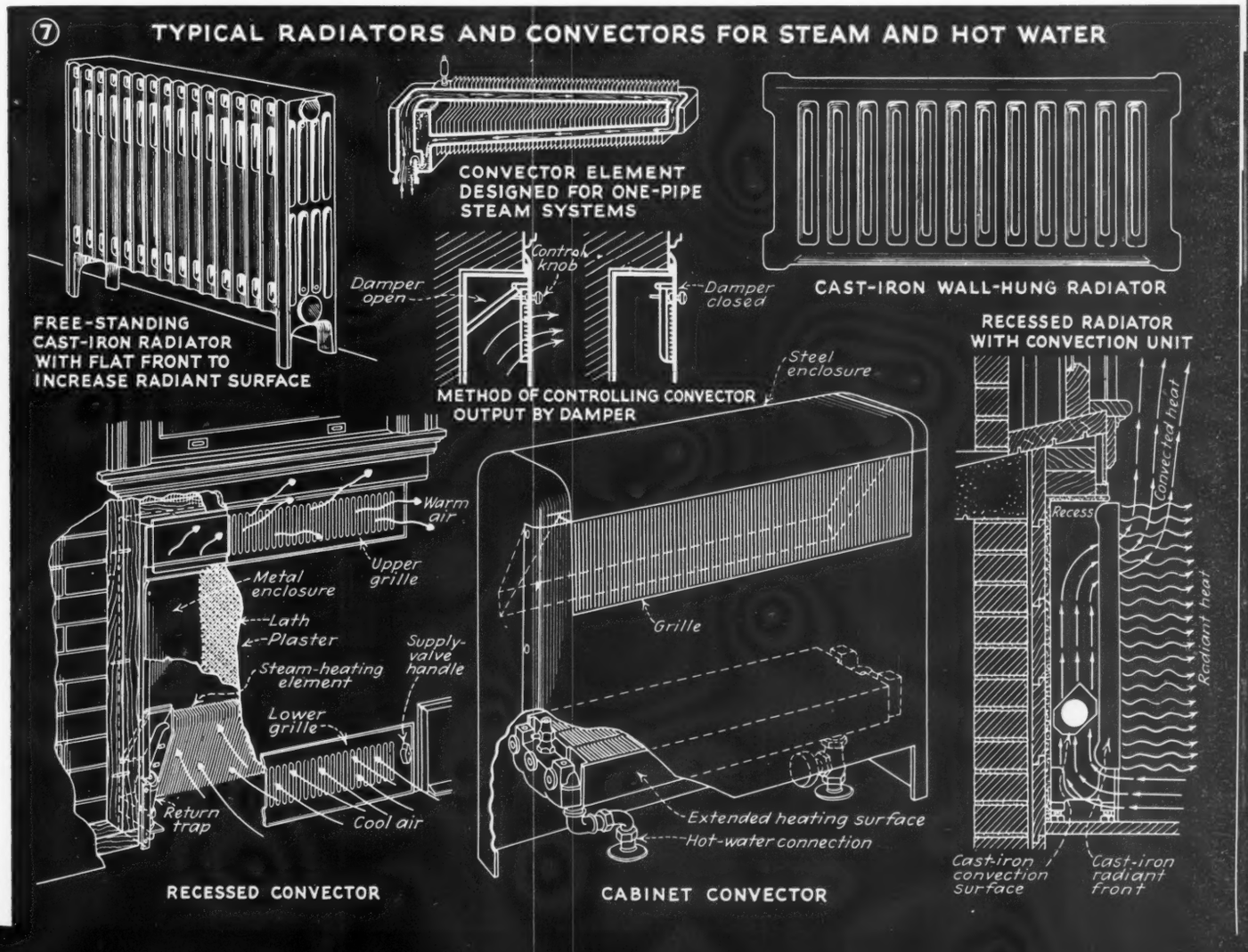
Unit heaters, combining steam or hot-water heating surface and a fan for air circulation, find wide use in industrial buildings. Forced circulation makes possible vastly higher heat-transfer rates which means a lighter, cheaper heating element for a given job. The fan contributes positive circulation in the heated space and so reduces the temperature differential between floor and ceiling. Flexibility and installation ease are other advantages.

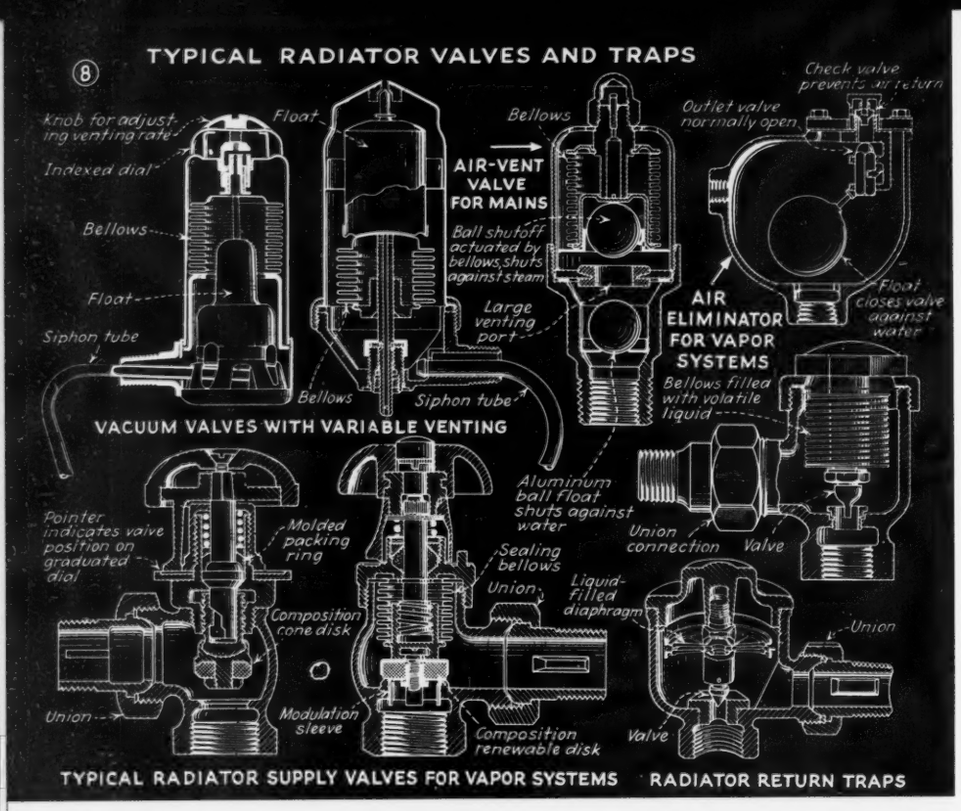
There are three basic unit-heater types: the suspended propeller-fan unit, the vertical high-velocity unit and the housed centrifugal-fan unit. Each has its special field of usefulness. Suspended propeller-fan units consist of an extended surface heating coil mounted in a suitable steel housing with a direct-driven fan mounted behind. Louvres direct the air stream.

In vertical heaters, the fan lies in a horizontal plane and may draw air through the element instead of pushing it through. Higher outlet velocity produces greater "throw", generally in a downward direction. These characteristics make vertical units particularly suited for mounting at high levels, although with proper diffusing outlets they can be mounted on low ceilings.

Housed centrifugal fan units offer high capacity for heating large spaces. The centrifugal fan works better against high resistances than does the propeller unit; high outlet velocities and long throw are possible. Floor units draw air from low levels, keeping the floor-ceiling differential to a minimum. Centrifugal fan units are also designed for wall and ceiling mounting.

Direct-fired unit heaters, fitted with gas burners, oil burners, or stokers can be installed where no central supply of





steam or hot water is available or in isolated parts of a plant where it would be troublesome or uneconomical to pipe steam or hot water. Electrically heated units are also available.

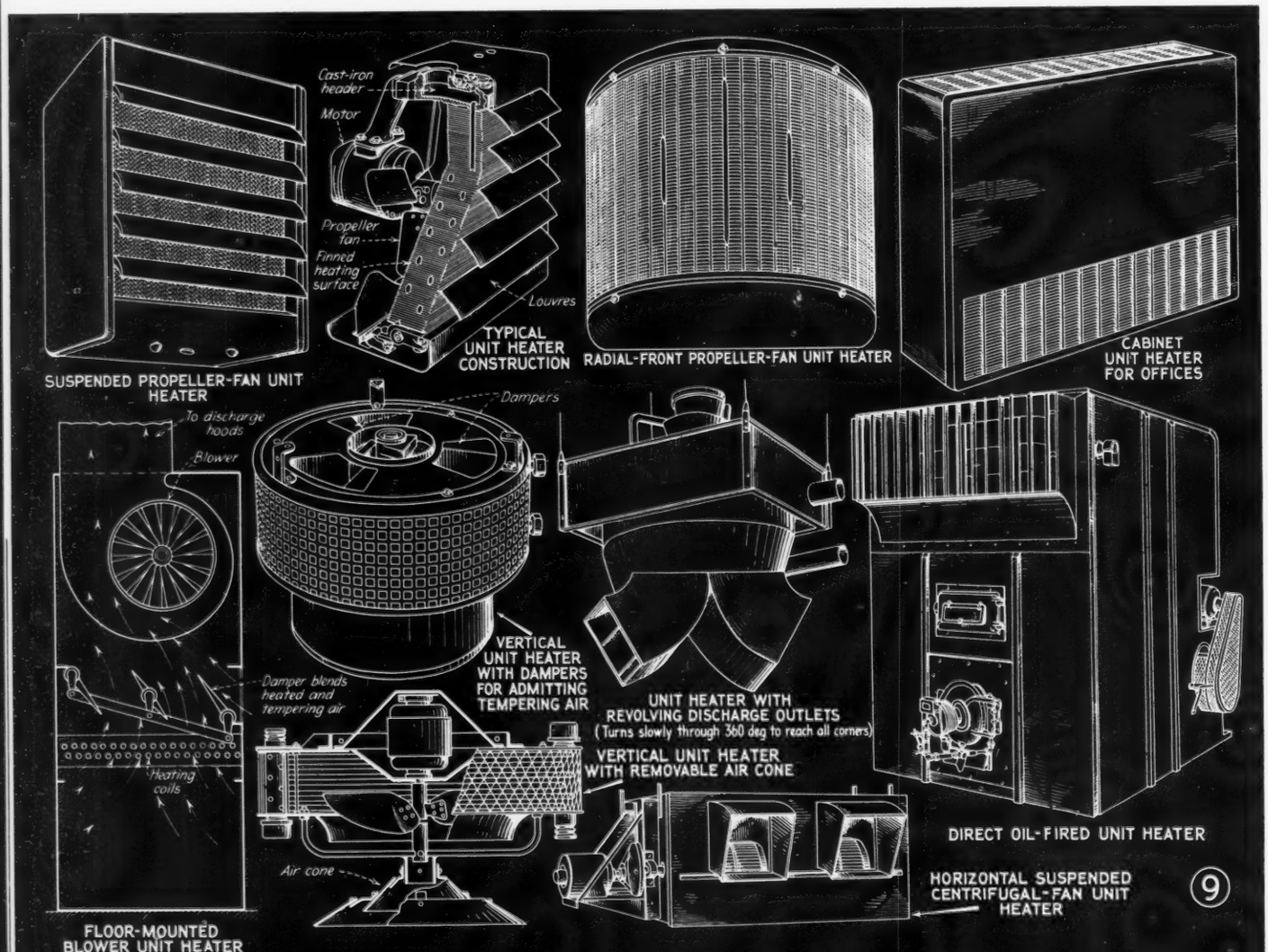
Unit heaters are rated in Btu per hr based on 60 F entering-air temperature and 2 lb steam. In choosing heaters, consideration must be given to amount of air handled as well as to heat output; in general, it is desirable to circulate large volumes of high-velocity low-temperature air, as this tends to reduce stratification and give more uniform temperature. Industrial atmospheres, containing acid or other corrosive fumes require special attention.

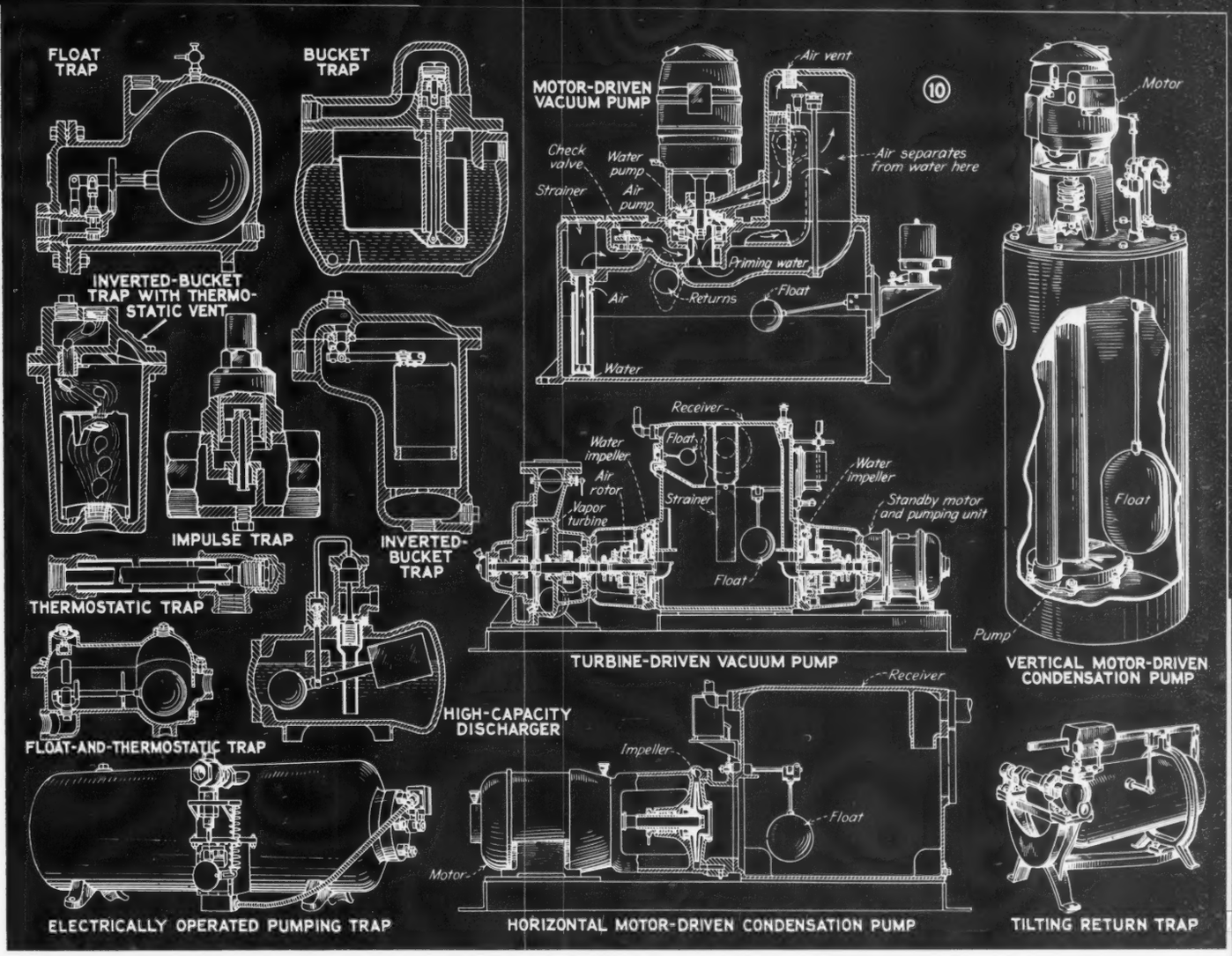
Heaters are generally located to blanket exposed surfaces with warm air, the air stream wiping the wall at an angle. If heaters are too close heat loss will be excessive; if too far away space near the wall will be cold. Heaters should be just far enough away to let velocity dissipate; low-velocity air will mix intimately with cold infiltering air, heating the area near the exposed surface with maximum effectiveness.

Vertical blow heaters give more or less symmetrical distribution and heaters are usually placed so the edges of the areas covered touch or overlap. Downblow heaters are particularly effective in combatting cold infiltration at doors, etc. (For a comprehensive discussion of unit heater types, construction, selection, location, piping, and control, see POWER, October 1940, January and February, 1941).

Radiator Valves, Traps

On certain types of steam systems, provision must be made at each radiator or convector for eliminating air. This may be no more than a hand-operated petcock, but normal practice requires an automatic valve with a





thermostatic element to close the vent when steam reaches the valve. The rate of heating-up of any individual radiator depends on its location and the resistance the steam must overcome in reaching it, and also on the rate at which air is expelled. By providing an adjustable orifice in the air valve, this device can be used to "balance" a system. Radiators which fill rapidly with steam can be slowed down by reducing the air-vent orifice and the filling of others can be speeded by enlarging the orifice.

Vacuum valves vent air and seal the system against its return; this results in maintenance of a partial vacuum when steam pressure goes down, thus keeping radiators warm longer. Likewise, radiators warm faster when steam pressure increases. On intermittently fired systems, it is desirable to permit the system to fill with air before the burner starts; this may be effected by a solenoid valve that opens when the thermostat calls for heat, or by a vacuum valve designed to open after holding vacuum for a short time. Vacuum valves are also fitted with adjustable air-vent orifices.

Angle valves with hard-rubber renewable disks and unions for connection to radiators form the ordinary supply valves. The valves illustrated are designed for vapor-system service and feature "packless" construction; in one a bellows seals the stem opening while the other uses a semi-permanent molded-ring packing. These valves require less than a full turn to go from open to shut. They can be fitted with disks suitable for modulated control of the steam supply and with indicating dials to show valve position.

Radiator traps are normally of the thermostatic type, having a diaphragm or bellows filled with a volatile liquid.

Fig. 10 shows traps suitable for handling larger quantities of condensation from blast coils, unit heaters, steam mains, etc. *Ball-float* traps discharge continuously, the rate depending on the condensate level. *Open-float* or *bucket* traps discharge intermittently; condensate rises until it overflows into the bucket and sinks it, opening the valve. Inlet pressure drives condensate out and restores bucket buoyancy. The *inverted-bucket* trap stays open as long as condensate fills the body and bucket. Steam caught in the top of the bucket causes it to rise, closing the valve.

Most inverted bucket traps have a hole in the bucket top to vent air, but for fast elimination of large amounts a thermostatically controlled vent may be added. Addition of such a thermostatic vent to the float type of trap makes the well-known *float-and-thermostatic trap.*

The illustration also shows another type of *thermostatic* trap, which uses the expansion and contraction of a bimetallic element to operate the valve. The *impulse* trap depends on the recently recognized fact that the pressure in the space between two orifices in series varies with the temperature of the fluid flowing. The high-capacity *discharger* uses a pilot valve actuated by motion of the displacement beam.

Traps are rated in lb of condensate per hr. Intelligent use of rating tables calls for a clear understanding of the basis on which the ratings were determined and, second, a firm grasp of the principle that capacity of a trap with a given size of orifice depends on pressure drop. Less pressure drop means less discharge. Pressures are those measured in the trap inlet and outlet. Most rating tables give the discharge for different pressure differentials, for each orifice size.

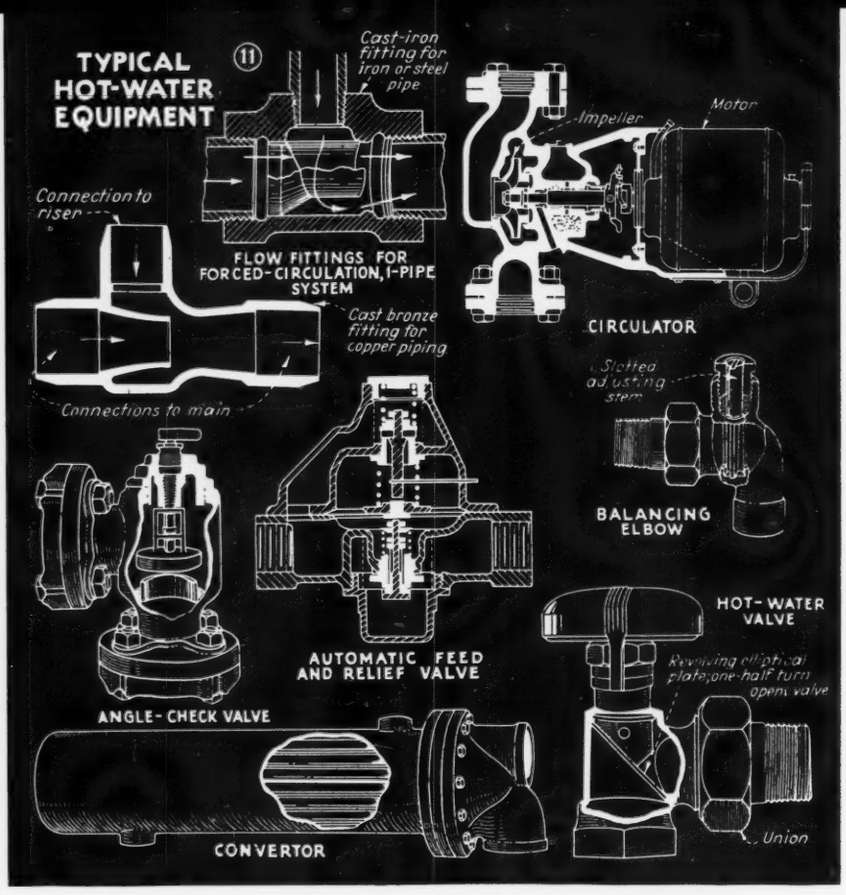


Fig. 10 shows two *return traps*. These are devices to feed water against boiler pressure. The tilting trap shown operates when the amount of condensate in the body overcomes the counterweight and tilts. This opens a valve admitting boiler steam, and closes the vent to build up boiler pressure in the body. With pressures equalized, water flows to the boiler by gravity (the trap must be placed at least 3 ft above boiler water level). Loss of water allows the counterweight to tilt the body back, closing the steam valve and opening the vent. Condensate again flows into the body until the cycle is repeated. Traps of this type are made in a number of forms.

A somewhat different return or *pump trap* is shown also; water rising in the tank of this trap actuates a float which controls the opening and closing of solenoid valves. The principle of equalizing boiler pressure to permit gravity feed is similar to that of the trap described above but operation is electrical instead of mechanical. This and other return traps can be used for lifting condensate to higher elevations instead of for boiler feeding. The height depends on boiler pressure.

Pumps

Although any pump having proper head and capacity characteristics would serve to return condensation, compact special units have been developed to give maximum satisfaction in this service. Fig. 10 shows two types, one horizontal and the other vertical. In each case, motor, pump, receiver and control are built into a single unit. A float switch controls the motor in accordance with changes in water level.

Vacuum pumps must both return condensation to the boiler and remove air from the system. In the turbine-driven pump illustrated, water and air are separated before pumping. A rotor-type water-sealed pump handles the air to maintain vacuum and a centrifugal impeller handles water. The turbine operates on a 2.5 lb differential on heating system steam which is exhausted back into the system.

Another type of vacuum pump uses a water jet ejector for air removal, and the motor-driven unit shown handles air and water together in the air pump; after separation the boiler-feeding impeller handles water alone.

Vacuum pumps may be rigged for continuous operation or for automatic control. In most cases automatic control is arranged to start the pump if vacuum drops below the regulated point or when water level rises in the tank or receiver.

Recent attention has focussed on the 1-pipe forced-circulation hotwater systems for low-cost installation on small and medium-size jobs, Fig. 11. Heart of the system (see Fig. 11) is the small motor-driven circulator designed for ease of installation and quiet trouble-free operation. These units are usually just ahead of the boiler, discharging into it. Their design is suitable for booster service on sluggish gravity hot-water systems or in domestic water systems where pressure is inadequate.

The fittings shown connect risers to the main and are designed to divert a portion of the water into the radiator. The fittings also stratify flow in the main so that supply for a radiator is picked off the top of the stream and return water is brought back to the bottom of the main. This tends to reduce the temperature difference between radiators that would normally result from mixing returns from one radiator with the supply for the next one upstream.

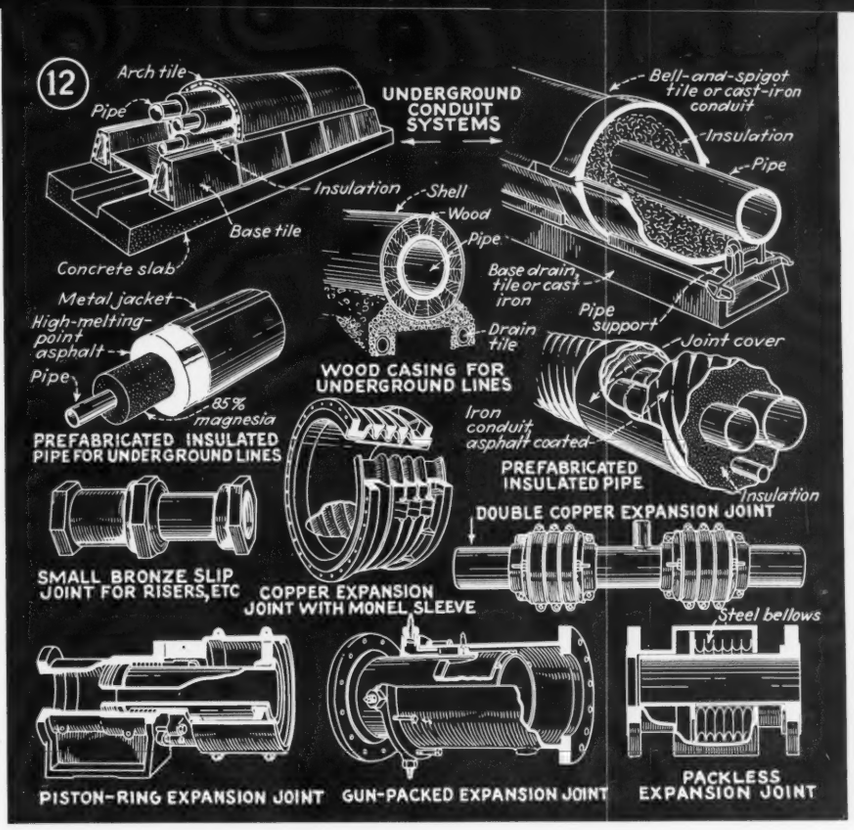
The angle check valve shown is normally installed at the boiler outlet to prevent reverse flow; in a zoned system a valve of this type would be used in each zone. The valve next to the check combines two functions: it automatically relieves excess pressure in the hot-water system and also automatically admits makeup water as required. The heat exchanger or convertor generates hot water from steam.

The radiator valve illustrated achieves a large free opening by a unique construction; motion of the elliptical plate opens or closes the valve. Balancing fittings, similar to the one shown, are used to make a semi-permanent adjustment of flow to a given radiator so that its heat emission matches the heat loss of the room.

Insulation

It has been said that all heat emitted inside a building goes to heat the building and so is useful. If this were entirely true there would be no real need for insulation of pipe and other surfaces. Actually, a heating system puts the right amount of heat where it is needed and in this job insulation plays an important part.

For high-temperature steam (above 300 F say), 85% magnesia, glass wool, or similar materials can be used. On low-pressure steam and hot-water lines, a lower-cost *air-cell* insulation is commonly used. This latter is made up of plies resembling corrugated paper but the material is asbestos felt. Most insulations for heating piping are made in sectional construction for easy application. Good practice indicates some form of covering, usually, a canvas jacket. Makers of air-cell insulations have introduced numerous special finishes to eliminate need for canvas jackets and to improve appearance. These include a glossy white pyroxlin finish that is dust, water, oil, and grease proof and easy to clean; and a heavy



asbestos-felt covering factory-painted with an asphalt-base aluminum paint.

Many installations require heat to be transmitted over large areas from a central point. Steam proves the most satisfactory medium because of the large amount of heat it carries per lb. Underground installation in masonry tunnels or trenches is common where exposed steam lines would be unsightly or in the way; cheaper overhead lines are often used in industrial plants.

There are two general forms of underground steam piping: those employing conduit carrying insulation and pipes, and those employing prefabricated insulated piping. Fig. 12 shows typical examples of both methods. One forms the conduit of arch and base tiles carried on a poured concrete slab; roller pipe supports rest on the concrete. Pipes may be covered with sectional insulation or the conduit may be filled with a fibre insulation. Another system uses cylindrical conduit, bell-and spigot, made of either tile or cast iron, mounted on a base drain that carries the pipe supports. Sectional or loose-fill insulation may be used. The drawing also shows an underground construction employing wooden pipe casing.

One type of prefabricated insulated pipe consists of an asphalt-coated conduit carrying insulation and piping. These come in standard lengths and are connected as shown. Fig. 12 also shows a prefabricated insulated pipe made by covering bare pipe with 85% magnesia and inserting in an oversize metal jacket. Into the space between insulation and jacket is poured high-melting-point asphalt, which hardens to form a lasting protection.

In a steam line of any length, expansion must be allowed for, either by providing loops in the piping or by installing some form of expansion joint. Various forms of sliding expansion joints have been developed, ranging from a simple unit designed for risers and other small piping, to the cylinder-guided unit shown in Fig. 12, which has special glands and stuffing-boxes.

Various forms of packless joints are also available; the drawing shows a corrugated copper joint with Monel sleeve for use with superheated steam, also a copper double joint with welding ends. In another type the cylindrical guiding principle is combined with the corrugated sealing arrangement.

Warm-Air Equipment

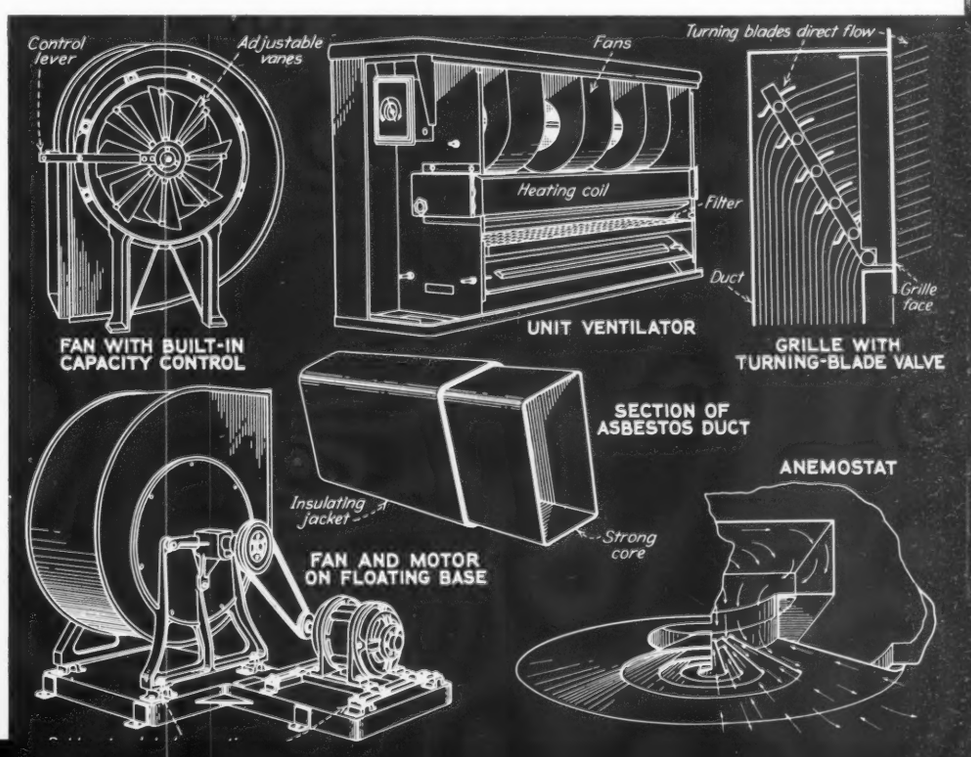
Basic warm-air heating equipment includes fans for moving the air, ducts for carrying it, and grilles and outlets to discharge it into the room. There are two broad classes of fans: axial-flow or propeller fans which are suited to moving large quantities of air against low resistance, and radial-flow or centrifugal fans, suitable for use against higher resistances.

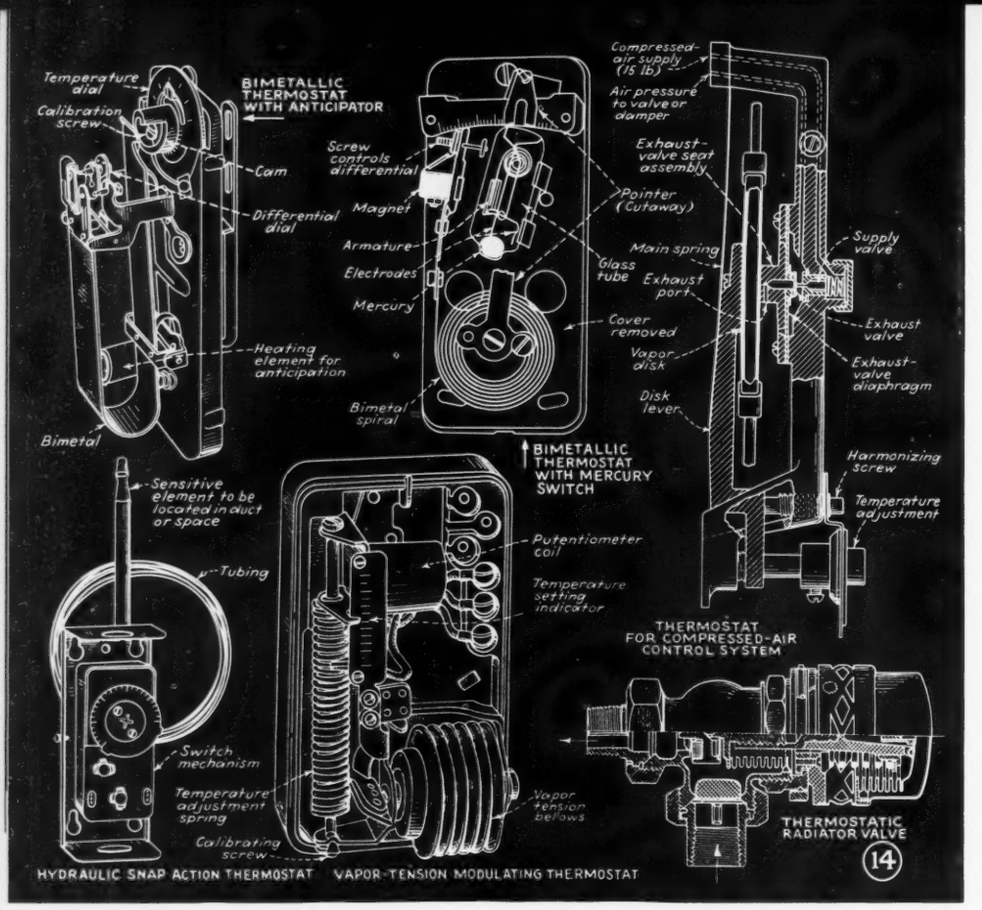
Fan output may be adjusted by dampers in the duct, by means of adjustable vanes at the fan inlet, or by varying fan speed. The drawing shows a fan fitted with adjustable vanes; similar vanes may be installed in a fixed position to reduce fan output semi-permanently without throttling.

Sheet-metal ducts are commonly used but a newly developed asbestos duct offers certain advantages, including built-in insulation and sound absorbing qualities. The illustration pictures a section of this duct.

In the simplest case, air is admitted to a room by means of a grille or register at the duct end and a similar opening is provided on the return side. Ordinarily such openings are equipped with a damper behind the grille face to permit shutoff; the illustration shows a special form of damper with turning blades to control direction of flow from the outlet.

The Anemostat shown provides a high-degree of diffusion by creating a multiplicity of air currents which move at angles to each other and produce an aspirating effect, drawing room air in to mix with treated air.





Controls

▶ NEED FOR HEAT IN A BUILDING changes continually, reflecting differences in both outside and inside conditions. Outdoor temperature varies from hour to hour during the day and from day to day during the year, as do wind direction and velocity. Each day the sun travels from east to west and day by day the path of its traverse shifts slightly. Part of the day the building is occupied, and part unoccupied; some spaces require higher temperature than others. Too little heat means discomfort and complaints, too much he t spells waste. Thus the basic job of any control method is to supply the right amount of heat, at the right time and in the right place.

Changing the amount of heating medium supplied or changing its temperature regulates room temperature, which is usually taken as a rough measure of comfort. This is done by valves or dampers, which are the "front-line" control devices. In the simplest cases, these are operated by hand. Adding some means of power operation permits remote control.

This general kind of arrangement might be called semi-automatic; the final control still rests on a human operator. If a thermostat, or other device which will react to change in conditions, is substituted for human control, we have a fully automatic system. Since thermostats and similar devices rarely produce impulses strong enough to operate valves and dampers, these latter must be power operated.

Thermostats differ in the kind of element used to respond to temperature changes, in their action, which may be "on-off" or gradual, and in the means by which their impulses are transmitted to the controlled equipment. There are three commonly used elements: bimetallic, hydraulic, and vapor-tension. In the first, a bent or coiled strip made of two metals having different rates of expansion changes shape as temperature changes; this motion can be used to actuate a switch or relay. In hydraulic systems the expansive force of special liquids is utilized to actuate a bellows, piston, or diaphragm. A vapor-tension system is charged with a highly volatile liquid which vaporizes at ordinary temperatures; the vapor pressure set-up varies in proportion to temperature, actuating a bellows, piston, etc.

Normally, bimetallic elements are used for positive or "on-off" control in conjunction with an electric relay or switch. The action of hydraulic and vapor-tension elements is essentially gradual, proportionate to temperature change, although they will provide positive action equally well.

Thermostats control equipment such as valves and dampers by any one of three methods: electric, hydraulic, or pneumatic. In electric systems for "on-off" control, the thermostat element actuates a switch or relay controlling operation of a solenoid or motorized valve or damper, or the starting and stopping of a burner motor, fan motor, etc. In electric hookups for gradual control the Wheatstone-bridge is used.

The hydraulic system is the only one of the three that is self-contained. As normally applied, expansion of liquid in the bulb carries back through connecting tubing to a bellows, piston, or diaphragm which forms the power source. An interesting combination of electrical and hydraulic control marks the damper motor shown on the next page, in which a flow of current from the control devices heats an expansive liquid, lever arm causing motion.

Pneumatic Systems

In pneumatic systems, compressed air provides the motive power to operate valves and damper motors. Thermostats control the operation by changing air pressure in the system. Changes in pressure actuate the bellows or diaphragms that power valves or damper motors.

The average heating system is controlled by temperature. Where humidity control is required, a hygrostat or humidistat is used. These resemble thermostats but the active elements consist of hair, wood, silk, or gold-beater's skin, all of which change dimensions with relative-humidity changes.

Thermostats are built with the active element and the operating mechanism in a single case for mounting directly in the room or space to be controlled, or with the thermostatic element and the operating mechanism separated so the bulb can be placed in a duct, strapped on a pipe, or immersed in water.

Control systems combine these basic equipment elements in countless ways, depending on the heating medium, the equipment hookup, and the conditions of exposure and occupancy. This section can only point out general principles and commonly used arrangements.

Simplest control is by adjusting the firing rate in boiler or furnace to match roughly heat needs, as in the familiar hand-fired residence steam system. Combustion rate can be controlled automatically by damper regulation on hand-fired units or by regulating operation of automatically fired burners. Burners are commonly controlled by intermittent operation, firing at full rate when "on," although it is possible to adjust the firing rate to the heat needs with certain types of equipment.

Somewhat greater accuracy and much greater flexibility characterize control by varying the quantity of heating medium circulated, or its temperature.

Quantity can be adjusted by changing the rate of flow or by intermittent flow with varying "on" and "off" periods.

Control by a single thermostat or by centralized manual adjustment proves reasonably satisfactory in small buildings where differences in conditions from one part to another are not great, but obviously cannot be applied to a large building without some provision for individual adjustments. In many cases, the central supply of heat is limited to prevent either over or under heating, and manually operated radiator valves or dampers permit the occupants to make closer adjustment for their own proferences. In theory, at least, individual thermostatic control would be ideal but the necessary high cost and complication bar its use in the average case. Self-contained thermostatic radiator valves, or valves and dampers controlled by thermostats located in another part of the room, form the usual equipment for this arrangement.

The practical solution to the problem of supplying varying quantities of heat to different parts of a building lies in dividing the piping or ductwork so that areas with different heat requirements are segregated and can be supplied separately. This is called *zoning*. A common form of zoning divides the building into north, east, west, and south zones to meet changes in sun exposure and wind direction. For economy, north and east, and south and west, zones can be combined. Zoning is used where differences in occupancy produce difference in temperature requirements or in hours of heating.

It is important to recognize that heating-system control in a large building rarely aims at close temperature regulation but rather at maintaining heat supply in rough balance with heat loss, thus preventing either over- or under-heating. The control system may perform other functions as well, such as starting the system in the morning, reducing temperature at night, etc.

Controls for Steam

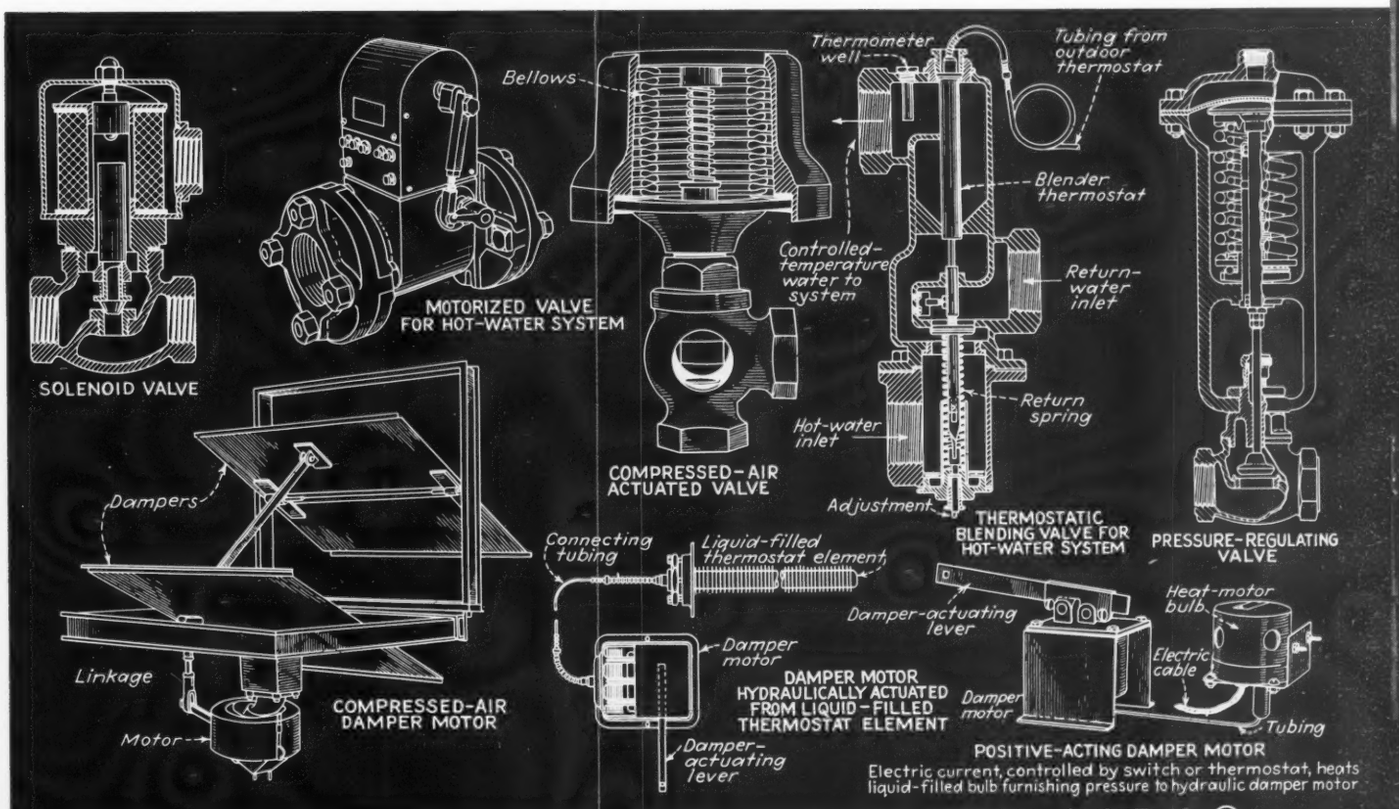
Steam-System Control: Simplest to understand is control by regulating quantity of steam supplied and simplest example would probably be installation of a pressure-regulating valve in the supply main of a 1-pipe system. With such a hook-up, total steam supply would depend on pressure setting of the valve, but distribution of steam to individual radiators would depend largely on the piping resistance to be overcome in reaching them. In 2-pipe systems, distribution among radiators can be regulated by means of *orifices*.

Physically, an orifice consists of a small disk with a hole in the center; it is inserted in the supply pipe or in the tailpiece of the supply valve. The orifice introduces a carefully calculated artificial resistance to balance the natural resistances of the system and to insure proper distribution. In an orificed system the pressure required to fill all radiators can be determined quite accurately; any lesser pressure will fill them to a proportionate amount. Thus control of pressure from a central point provides a simple and satisfactory control when combined with orifices.

Where setting of pressure is left to the operator, it is customary to set up a schedule of outdoor temperatures and the proper corresponding steam pressures, to serve as a guide to operation. For automatic operation, an outdoor thermostat (bimetallic or liquid-filled element properly shielded from sun rays and protected from weather) actuates the valve.

One system of this general type, electrically operated, has a main valve positioned by an outdoor thermostat which works in conjunction with a device to compensate for changes in steam supply pressure. In addition, a remote manually operated control permits the operator to increase or decrease steam flow from that determined by the thermostat, to compensate for high winds or to take advantage of bright sunshine and other weather factors decreasing heat needs. Still another system provides compensation for supply pressure changes, using hydraulic and mechanical equipment.

These systems operate with practically continuous flow of steam; another class of controls operate to vary quantity of steam supplied on an intermittent basis. The number of possible combinations is large, ranging from a simple timing-switch arrangement to completely automatic systems. For example, for any given system it is possible to determine the number of minutes of heating required in each hour to meet a certain outdoor temperature condition and a program switch can be set by the operator to give this timing. In general, it is desirable in such hookups to keep the time cycle as short as possible, particularly the time the system is shut down.



TYPICAL POWER-OPERATED VALVES AND DAMPER MOTORS FOR CONTROL SYSTEMS (15)

An automatic system operating on this principle consists of an outdoor thermostat which selects the proper "on" period for the prevailing temperature and actuates relays controlling opening and closing of a main valve. Pressure controllers hold a constant differential between supply and return. A manual control permits the operator to increase or decrease the "on" period to compensate for weather conditions or changes in demand. When several zones are each equipped with a control valve, the operation is synchronized so that valves are not all open at once and causing a heavy peak load on the boiler.

Combined continuous and pulsating flow feature an automatic control system employing a main valve with four ports. Two indoor thermostats are used, one wall mounted and the other on or near a typical radiator. At startup, one port of the four is open for gradual heating of pipes and then all ports open to warm up the building. As the building nears desired temperature, the main or wall thermostat starts closing down the valve ports until correct flow is established. When the flow through one port is more than required to hold temperature, steam is released into the system in short cycles caused by rise and fall of radiator temperature.

In systems operating at low pressures, such as vacuum systems, a small change in pressure makes a substantial change in steam temperature; this property is used as the basis for control in *sub-atmospheric systems.* In one such system, a thermostatically controlled valve regulates steam supply pressure from about 2 lb gage down to about 25 in. vacuum, giving a temperature difference of about 218 to 133 F, or a capacity reduction of about 57%. The vacuum pump is controlled to maintain a constant differential between supply and return sides. If more than 57% capacity reduction is required steam volume is cut and radiators are partially filled.

Control of Combustion

Another sub-atmospheric system controls supply pressure by regulating combustion rate. The operator sets the steam pressure according to the weather or demand requirements and a controller responsive to temperature and pressure in the return line close to the vacuum pump regulates pump operation to maintain an adequate differential between supply and return pressure. The differential is not constant and is always as large as the temperature of the returns permits. The controls regulate firing rate to maintain the selected supply pressure, which can be changed according to a schedule showing pressures for various outdoor temperatures.

Hot-Water Controls: For small systems, intermittent control is usual; the room thermostat either controls burner operation or, in forced circulation systems, controls operation of the circulating pump while burner operation is regulated by an aquastat to maintain constant water temperature.

Better results are claimed for systems in which water temperature is varied and flow is continuous. An indoor thermostat may be used to regulate water temperature but several new arrangements feature an outdoor thermostat which controls blending of heated water from the boiler and cooled return water to produce the temperature needed for prevailing weather conditions.

Warm-Air Systems: Quantity of air supplied may be regulated by fan control or by dampers, but normal method of regulation is by changing temperature of air supplied or by supplying air intermittently to maintain desired conditions. Where air temperature is varied on systems using all fresh air, supply of steam to the heating surfaces must be regulated; in systems where fresh and recirculated air are mixed, control can be effected by adjusting steam supply, by varying proportions of fresh and return air or, more commonly, by a combination of both.

Instruments: Instruments and meters to indicate and record the various conditions affecting operation constitute an important adjunct to any control system. Where possible, instruments showing outside temperature, wind velocity and direction, and temperatures at strategic places in the building should be centralized in the operating space or the engineer's office. Records of inside and outside temperatures, of heating medium circulated, of fuel consumed and other operating factors will usually justify their cost by encouraging and promoting economical operation.

Operation and Maintenance

▶ BECAUSE HEATING SYSTEMS don't make much noise and look quite simple, they don't always get the careful operation and maintenance awarded to more complicated and impressive mechanisms. Yet nowhere does intelligent operation pay such high dividends.

Daily log sheets and monthly summaries should be kept as part of the plant routine and these should be constantly compared, on a degree-day basis, to note increases or decreases in cost and to check the performance of men and equipment. Such records and comprehensive operating schedules based on them are particularly important in plants which operate without automatic control.

Complaints from building occupants should be investigated thoroughly and promptly. This is, of course, important for good will, but more important in the elimination of defects in the system or its operation. The job shouldn't stop when trouble is "fixed"; steps should be taken to prevent recurrence.

Regular maintenance and inspection eliminates many complaints before they can be made. Normally, heavy maintenance is carried out in summer months. This is satisfactory if the job is done properly and if it is backed up by systematic inspection during the heating season.

Summer check-up should include testing of thermostatic elements and other trap mechanisms, checking of automatic controls, and testing of vacuum pumps to see if they pull as they should. Summer is the time for cleaning out the system, including vacuum-cleaning of ducts and stacks where necessary. Defective insulation should be repaired.

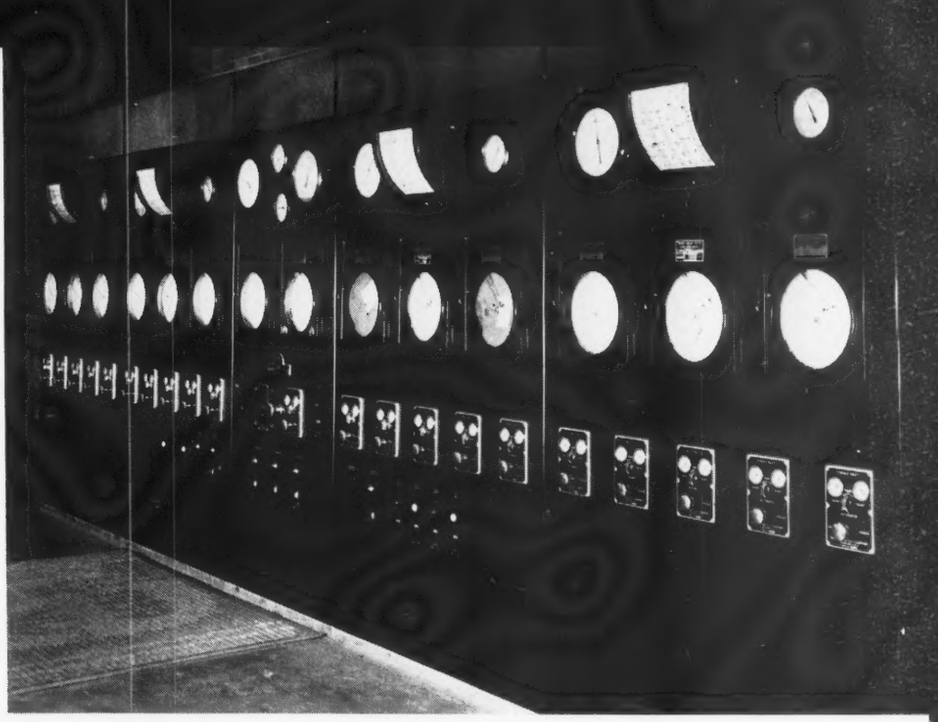
Summer is also the time to make changes in the system which winter operation has shown to be necessary or desirable. Such changes may include correction of faulty piping connections, improper pitching or dripping of lines, addition of quick vents at strategic places on mains, resetting radiators, installing additional or larger traps.

Outside of the system itself, summer is a good time to tackle sources of excessive heat loss. This means weatherstripping and caulking, possible addition of insulation at strategic spots.

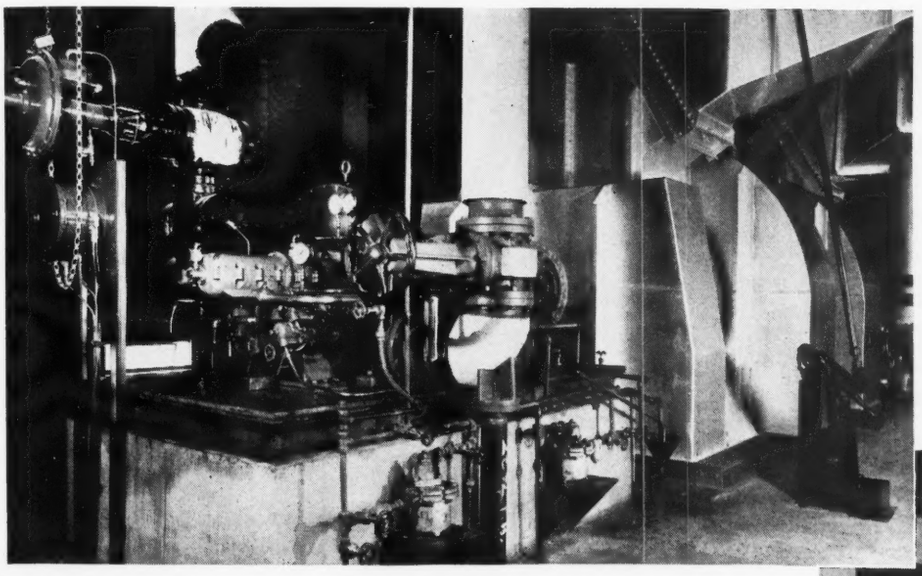
In all inspection work the engineer must be constantly on watch for signs of corrosion. Presence of oxygen and CO_2 encourage corrosion. A tight system will cut air leakage to a minimum and so reduce danger from this source. In some cases, deaeration and chemical treatment may be necessary. Use of corrosion-resistant materials may be the answer where conditions are severe. Watch for electrolytic corrosion at places where two dissimilar metals join. In hot-water systems, annual draining and re-filling may increase corrosion.

Parkchester in Pictures

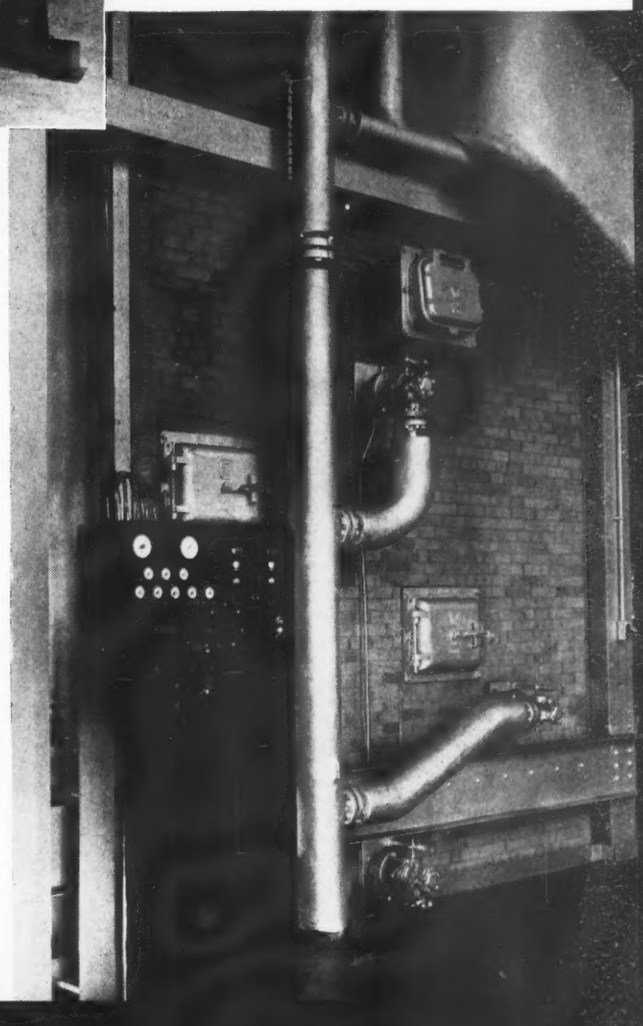
Additional photographs of the outstanding heating plant described on page 58



Complete centralization of boiler-plant control gives maximum operating effectiveness with minimum operating force. Master panel contains Bailey combustion controls, steam-flow air-flow meters, water-level recorders, temperature recorders for air and gas entering and leaving preheaters, recorders for temperature of feedwater leaving deaerator and of condensate in storage tank, and pressure recorders for fuel-oil and boiler-feed discharge. The panel also mounts controls for main steam valves and motor-driven auxiliaries, and alarms

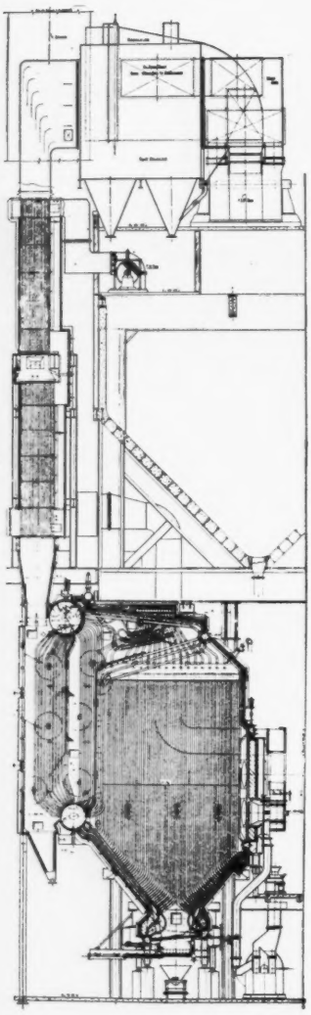


Duplex fan units above each boiler make a compact and simple layout. A single 300-hp variable-speed turbine drives both forced and induced-draft fans through a reduction gear. Automatic combustion control regulates turbine speed and damper position

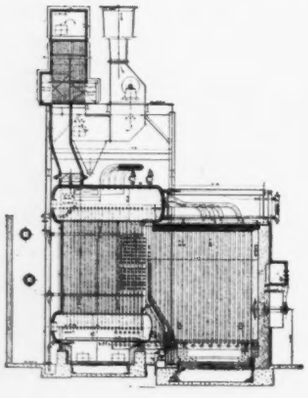


Complete automatic control of soot-blowing centers in a board like this on each boiler. Starting at the firebox, the five air-motor-actuated Vulcan elements steam-blow in sequence; an alarm informs the operator when the cleaning cycle is finished. Automatic operation insures regular and adequate blowing. Spreading the operation over a longer period of time decreases the amount of solids discharged from the stack at one time and likewise decreases the total discharge by making it more likely that solids will drop in the dust hoppers

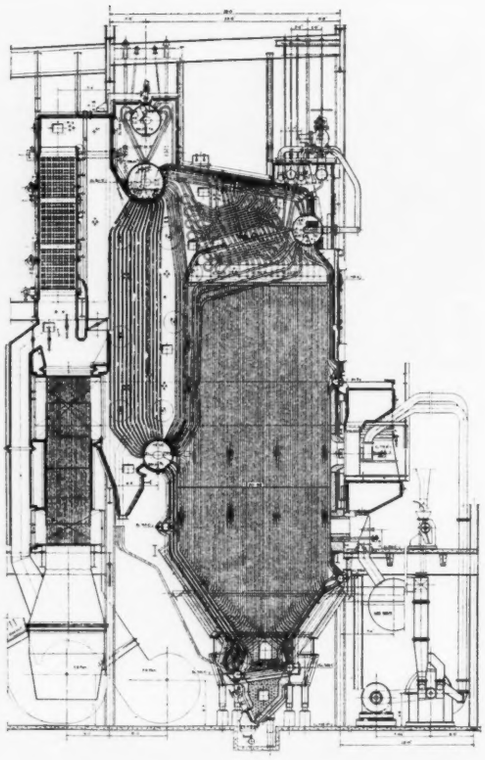
....Typical Recent Installations



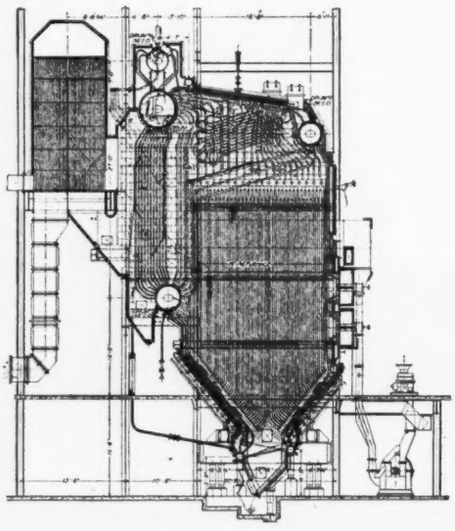
Union Electric Co. of Mo., St. Louis, Mo.
2-300,000 lbs./hr. 225 lbs.—520°F.
Fired by Riley Pulverizers
This company has recently ordered
2-400,000 lbs./hr. 1000 lbs.—915°F.
Riley Units



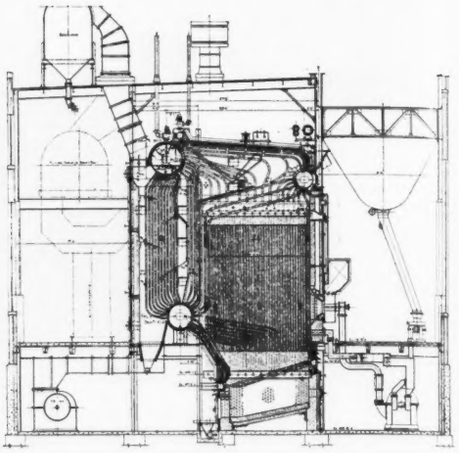
General Aniline Works
Grasselli, N. J.
40,000 lbs./hr. oil fired Riley
"RO" Unit
This company has also installed three additional larger
Riley Boiler Units



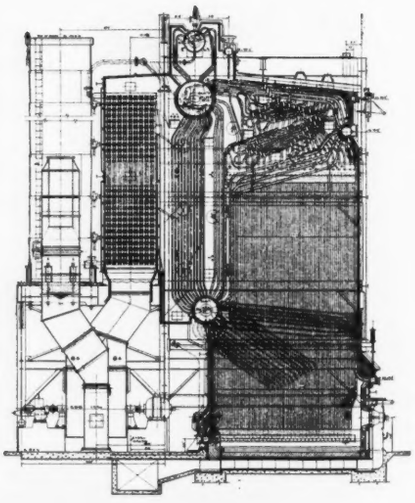
Largest Boiler in Steel Industry
450,000 lbs./hr. 500 lbs.—700°F.
Fired by Riley Pulverizers and Blast Furnace Gas



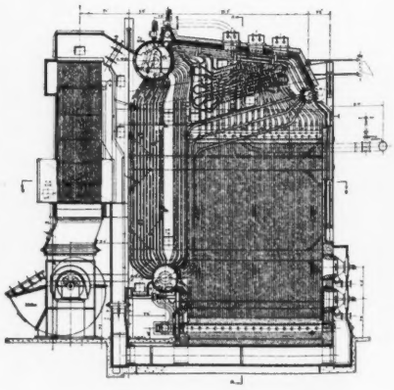
Scovill Manufacturing Co., Waterbury, Conn.
225,000 lbs./hr. 660 lbs.—750°F.
Fired by Riley Pulverizers



Henry Disston & Sons Co., Philadelphia, Pa.
3-85,000 lbs./hr. 575 lbs.—660°F.
Fired by Riley Pulverizers



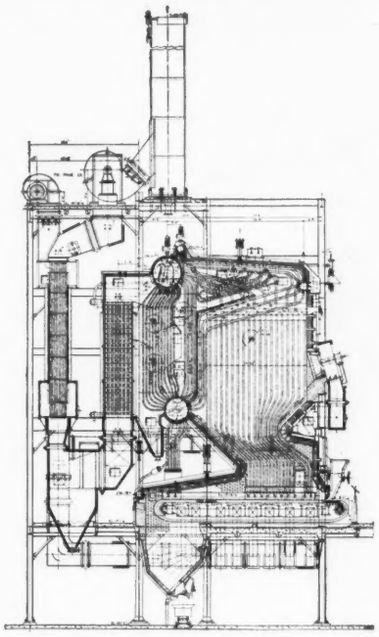
Humble Oil and Refining Co., Baytown, Texas
2-350,000 lbs./hr. 620 lbs.—740°F.
Fired by oil and gas



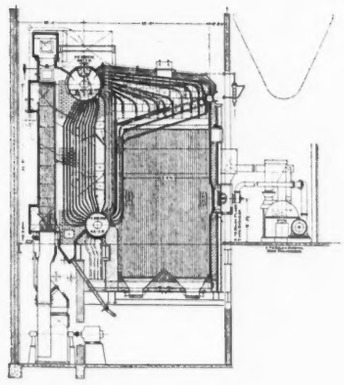
Large Texas Chemical Plant
5-300,000 lbs./hr. 500 lbs.—750°F.
Gas and oil fired

It will pay you to visit modern Riley Installations

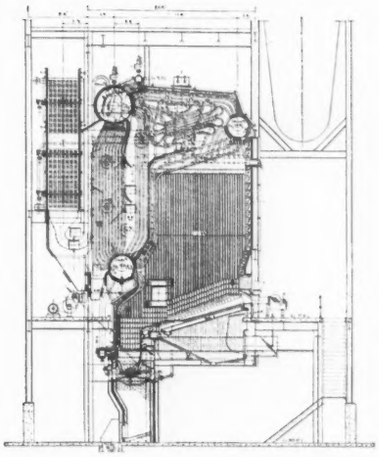
# of RILEY steam generating units



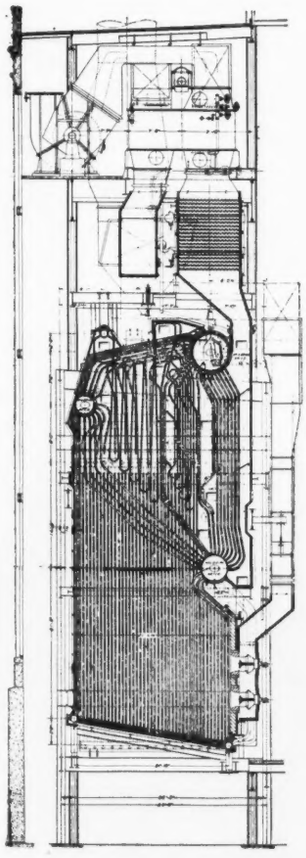
Continental Paper Co.
Ridgefield Park, N. J.
110,000 lbs./hr. 475 lbs.—700°F.
Fired by Riley-Harrington Stoker burning anthracite buckwheat. Designed for future pulverized coal and oil firing



Curtiss-Wright Corp., Buffalo, N. Y.
70,000 lbs./hr. Pulverized Coal Fired Riley Unit
This company is now installing 12 additional Riley Boiler Units at their Buffalo, St. Louis and Columbus plants



Consolidated Water Power & Paper Co.
Wisconsin Rapids, Wisc.
100,000 lbs./hr. 460 lbs.—700°F.
Fired by Riley Multiple Retort Underfeed Stokers



Large Florida Public Utility
300,000 lbs./hr. 900 lbs.—900°F.
Fired by oil

If you want to see modern steam generating equipment built as it should be built, visit any of the Riley installations shown or any other recent Riley installations.

When you do so you will find boiler equipment which meets today's demand for extreme economies and trouble-free operation . . . equipment which not only met guarantees but in many cases exceeded them. You will also be impressed by the excellent appearance of the equipment and realize that a casing so constructed is not only tight to start off with but stays tight after years of service.

Then it will be apparent to you why there has been such a decided swing during recent years to Riley Boiler and Fuel Burning Equipment . . . why so many of the country's leading industrial and central station plants have selected Riley equipment . . . why we are justified in saying "It will pay you to visit modern Riley installations before purchasing boiler or fuel burning equipment."

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Boston New York Philadelphia Pittsburgh Buffalo Cleveland Detroit Tacoma Baltimore Milwaukee Denver
St. Louis Cincinnati Houston Chicago St. Paul Kansas City Los Angeles Atlanta Memphis New Orleans

COMPLETE STEAM GENERATING UNITS

BOILERS • PULVERIZERS • BURNERS • STOKERS • SUPERHEATERS
AIR HEATERS • ECONOMIZERS • STEEL CLAD INSULATED SETTINGS
WATER-COOLED FURNACES • FLUE GAS SCRUBBERS

before purchasing Boiler or Fuel Burning Equipment

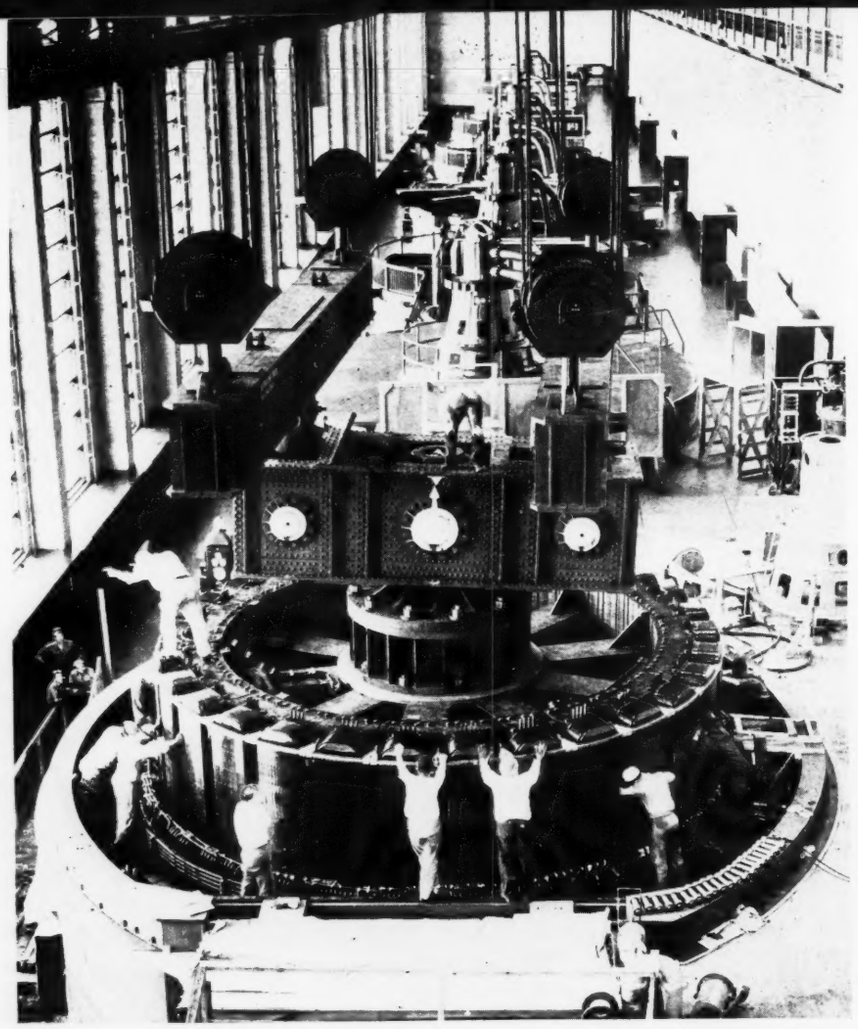
Threading the Hydro Eye

▶ ONE OF THE MOST INTERESTING JOBS in erecting a hydroelectric power station is the operation of lowering or "threading" the rotor into the stator. The two photos on this page show how the job is done for two different types of modern hydroelectric plants of practically the same head and with comparable-sized units.

The Safe Harbor plant of the Safe Harbor Water Power Corp, on the Susquehanna River in Pennsylvania, has seven main units installed, with each generator driven by a 42,500-hp, 100-rpm, adjustable-blade Kaplan turbine operating under 55-ft head. The photo shows the 300-ton rotor of the seventh generator, a single-phase, General Electric unit, being lowered into place by two cranes.

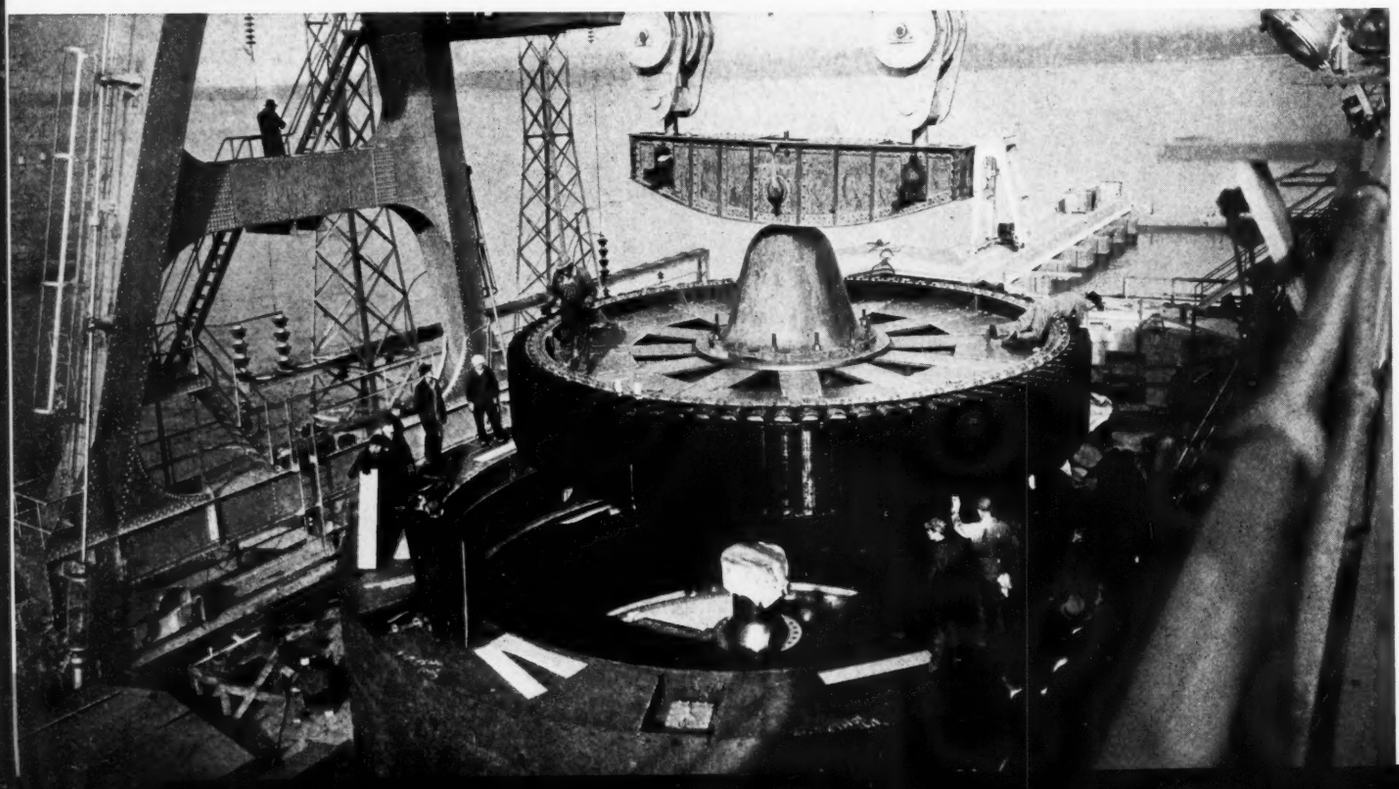
Each crane has two 125-ton lifting hooks; the hoisting and lowering is done from four points on a system of lifting beams. The large pointer on the beam next to the rotor tells whether or not the lifting beam is on an even keel.

The other photo shows the Wheeler Dam project of the TVA. This outdoor plant will have by the end of this year four 45,000-hp units in operation, each driven by a fixed-blade, propeller-type turbine at 85.7 rpm under 48-ft head. The substructure of the power house is spanned by a 270-ton gantry crane with two hooks, which are shown threading the 225-ton rotor into No. 3 generator, built by the General Electric Co.



Threading the 600,000-lb rotor into the stator of a 35,000 kva, single-phase generator at Safe Harbor. Rotor-to-stator clearance is only $\frac{5}{8}$ in. and the lowering operation requires special beams and two cranes, each with two 125-ton hoists

Workmen lower a 450,000-lb rotor into No. 3 generator, rated 36,000 kva, at the Wheeler Dam hydro plant. The power house is an outdoor design and the heavy equipment is handled by a 270-ton gantry crane with two hooks



Gearmotors—What They Are, How They Operate, When to Use Them

This survey of gearmotors includes vital data on efficiency and cost of operation, speed-ratio and horsepower limits, types of motors and gears used and their applications

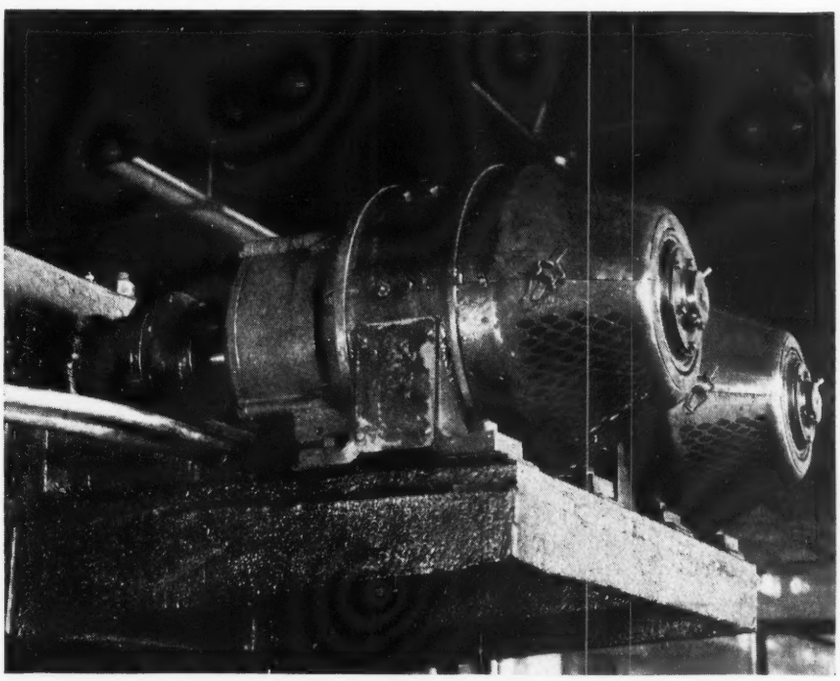


Fig. 1—Two dc, single-reduction gearmotors in a steel mill

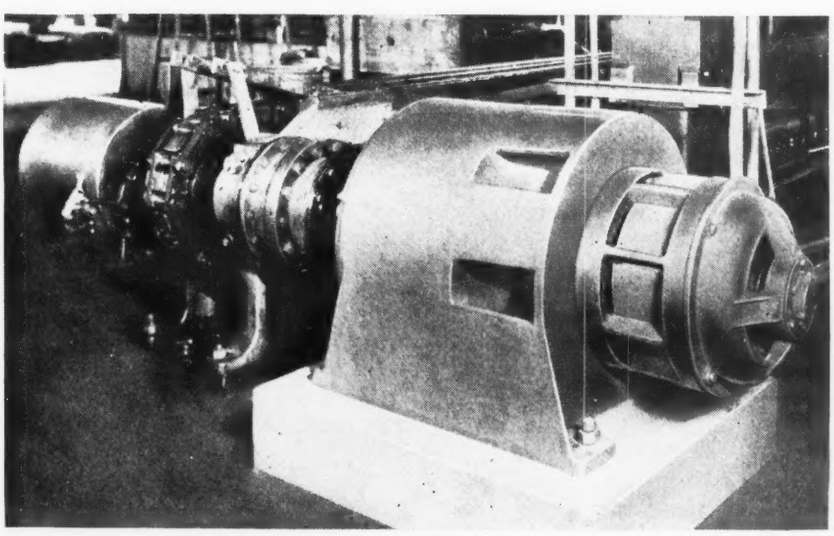


Fig. 2—A 30-hp, squirrel-cage, double-reduction, 17-rpm-output-speed gearmotor drives a draw-bench for making copper tubing

▶ COMPACTNESS combined with the correct speed to connect directly to the driven machine are deciding factors in many power applications. These requirements led to the development of motorized-gear speed-reducers now generally called gearmotors or motor-reducers. These units combine a high-speed motor with some type of gear speed-reducer. Because of their many advantages these units are used very extensively and are built by practically all motor and gear manufacturers.

These units are built in three forms. First, the gear-head motor, Fig. 1, where the speed-reducer is built in as part of the motor and is supported from its frame. In fact, the gear housing replaces the rear end bell of the motor frame. This construction is used for single-reduction gearing for ratios up to about 9 to 1. Such a unit for maximum speed ratio may, for example, consist of a 1750-rpm induction motor with a 9-to-1 ratio gear mounted on it for an output speed of 193 rpm.

Overhung Motor

For gear ratios higher than 9 to 1, when double or triple reductions are used, the torsional stresses of the low-speed shaft become too great for the motor frame and feet. As the weight of the overhanging gears is also excessive, the motor is overhung from the gear housing, which is made strong enough to support the gears and the motor rigidly, see Fig. 2. The motor is of standard-frame design without feet, arranged to be bolted directly to the gear housing.

A third design of motorized-gear speed-reducer mounts a standard motor on an extension of the reduction-gear frame, Fig. 3. In the other two designs the gear pinion is keyed directly to the motor shaft. In Fig. 3 both motor and gear are in their own housings, the motor and gear shafts being connected by a flexible coupling. This unit is not as compact as those shown in Figs. 1 and 2, but has the advantage that the motor can be readily exchanged in case of trouble.

These units combine the desirable

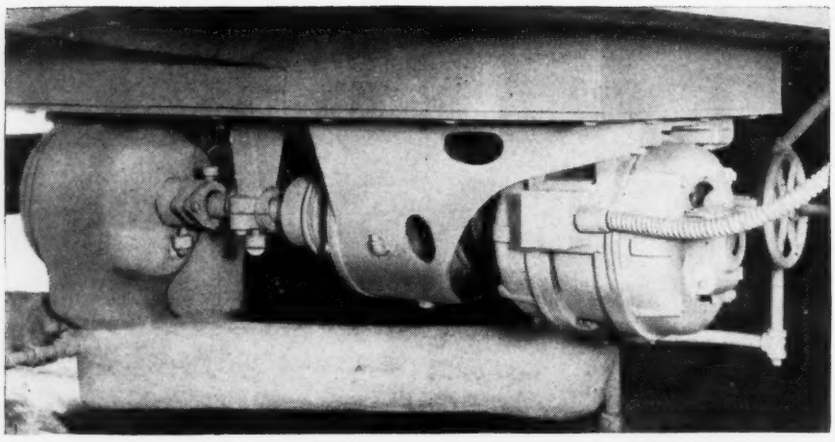


Fig. 3—20-hp, normal-torque gearmotor connected through an automatic clutch

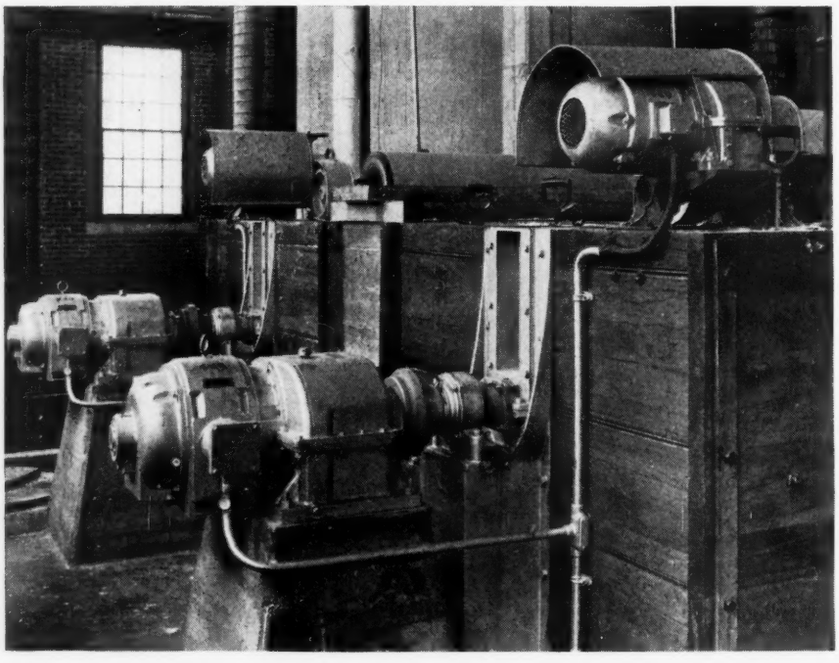


Fig. 4—Four splash-proof, double-reduction, squirrel-cage gearmotors give correct speed for driving the wet end of a paper machine

characteristics of a high-speed motor with a compact high-efficiency gear unit. The gear part of the unit generally has an efficiency of 96 to 98% for single-reduction and for double-reduction gears an efficiency of 94 to 96 may be expected. The high-speed motor not only has smaller dimensions and lower cost than a slow-speed design but it has a higher efficiency; when induction motors are used the power factor is higher. The latter is particularly important when power is purchased, for it may mean much lower power cost.

For example, consider a 5-hp unit. A 1750-rpm squirrel-cage induction motor of this size will have an efficiency of 86% at full load and 85% at half-load. The power factor of this motor at full and half load will be 0.86 and 0.72 respectively. A gearmotor with this motor built into the unit will have an over-all length of about 20 in. and will weigh about 180 lb, assuming an output speed of 430 rpm.

A 5-hp squirrel-cage motor designed for an output speed of 430 rpm has a full-load efficiency of 77%, a half-load efficiency of 73% and a power factor at these loads of 66 and 35% respectively. Therefore, at full load its efficiency is 86 − 77 = 9 and at half load 85 − 73 = 12 points lower than the 1750-rpm motor. The power factor of the slow-speed motor is 86 − 66 = 20 points lower at full load and 72 − 35 = 37 points lower at half-load than the high-speed motor. It will weigh about three times as much, will have an over-all length 1.6 times that of the gearmotor and will cost about twice as much.

Assume that these motors operate at full-load 8 hours a day, 300 days per year, and that power is purchased at 2 cents a kwhr, but with a clause in the contract which decreases the power bill 0.5% for each percent that power factor is above 85 and increases it 0.5% for each percent the power factor is below 85.

Full-load efficiency of the gearmotor will be 0.86 x 0.97 = 83.5% and its power factor 0.86. Power to operate this unit 8 hours a day for 300 days at full load will cost $215. Because of the lower efficiency and power factor of the 430-rpm motor, its power cost for 300 days will be $260, $45 more than for the gearmotor. Even where power factor is not an element in the cost, power for the slow-speed motor will be about 10% higher than for the gearmotor.

The example given is for one set of conditions which, of course, will vary widely with speed reduction, power rates, load on the unit and hours of operation per year. Generally, when the gear ratio is 2 to 1 or greater, the advantages of first cost, weight, over-all length and cost of operation are in favor of the gearmotor over a motor for direct connection to load.

Versatile Gearmotors

Another advantage of the gearmotor is that its output-shaft speed can be made almost any value to suit the driven machine, simply by selecting the correct gear ratio. With direct-connected squirrel-cage motors output speeds are limited to a few, such as 3500, 1750, 875, 680, 575 rpm, etc, depending upon the number of poles in the motor.

For many applications within their capacity limit, which is about 75 hp, gearmotors have advantages over separate motors and gear speed-reducers in that cost is lower. They are more compact and only one unit has to be maintained in alignment with the driven machine. With a separate motor and gear speed-reducer, even when mounted on a bedplate, alignment is not assured because the bedplate may be distorted on its foundations.

Small-capacity gearmotors are available for speed ratios of 3000 to 1. For capacities up to 10 hp, gearmotors may be obtained for speed ratios of 450 to 1. Where very large speed reductions are required the slow-speed reduction is frequently taken by a chain drive, Figs. 7 and 8. The extremely high torques at the very low speeds can, in general, be transmitted better by a roller chain than by any other type of transmission equipment.

Several types of gearing are used in

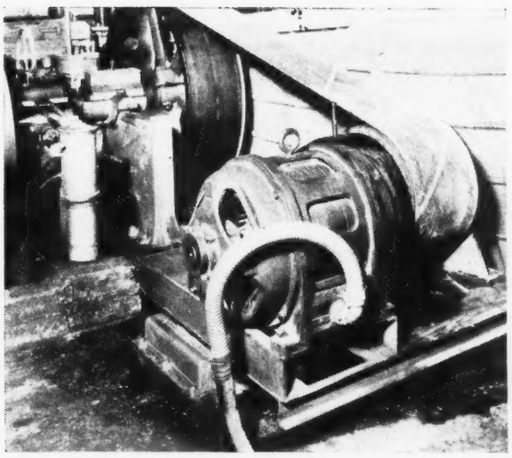


Fig. 5—1750-rpm gearmotor on a pivoted base is flat-belt connected for 12.5-to-1 reduction

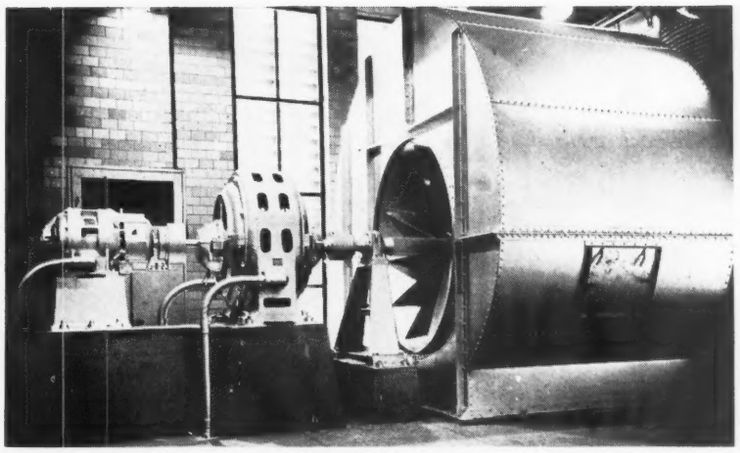


Fig. 6—31.5-hp, 230-rpm—4-hp, 115-rpm gearmotor connected to a 251-hp, 450-rpm—74.4-hp, 300-rpm squirrel-cage motor driving a large fan

gearmotors, such as spur, helical, herringbone, worm, straight or spiral bevel and hypoids. Spur and helical gears are frequently used in planetary arrangements, which have the advantage of giving a ratio of input to output speeds higher than the gear ratio. This permits a higher speed reduction in a given size gear casing than any other type gearing except worm gears. Planetary gearing also has the advantage that its output-shaft axis falls on the same straight line as does the motor shaft. With other types of gearing the output shaft is offset from the motor shaft.

On some designs of single-reduction units with offset shafts the gear casing can be bolted in four different positions on the motor frame to bring the output shaft to the most convenient position for connecting to the driven machine. Double-reduction non-planetary gearing may have the gears so arranged that the output shaft is concentric with that of the motor.

Parallel-shaft gears are usually made of steel, but where very quiet operation is required a non-metallic pinion is used. Where large speed reductions are required, worm gears are frequently used, for right-angle drives, worm gears, straight- or spiral-bevel and hypoid gears are employed. On right-angle drives the motor is mounted on the gear casing. These drives have the advantage of requiring small space because the motor is parallel to the side of the driven machine and not at right angles.

Gearmotor Types

Gearmotors are built with standard-type motors including squirrel-cage general-purpose types for normal-starting-torque and normal-starting current; for normal-starting-torque and low-starting-current; for high-starting-torque and low-starting-current; and for high-starting-torque, high-slip. Slip-ring alternating-current motors and direct-current motors are also used.

Gearmotors with general-purpose motors are applied where a normal starting current can be permitted and a normal starting torque will start the load satisfactorily, such as on low-speed fans, line shafts, light conveyor systems, etc. Units with normal-starting-torque, low-starting-current motors are used on the same applications as the general-purpose motors, but where the starting current must be limited because of power-system restrictions or other reasons.

High-starting-torque, low-starting-current gearmotors fit applications where a high-starting torque is needed, such as on stokers, pulverizers, heavy-starting conveyors and similar loads.

High-starting-torque, high-slip, squirrel-cage motors are applied to high-inertia loads, particularly those where a flywheel is used to absorb load shocks and on loads where starting and stopping is frequent. For a flywheel to absorb peak loads effectively the motor must slow down when the peaks occur, which high-slip motors will do. This type of motor is inherently a comparatively low-efficiency machine. However, where starting and stopping are frequent,

(*Continued on page* 136)

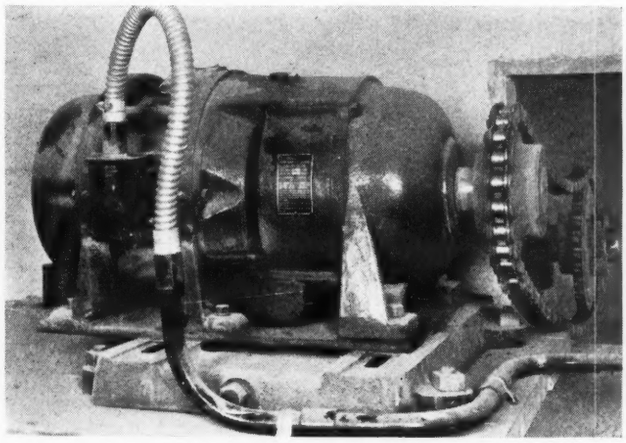


Fig. 7—Single-reduction gearmotor has single-strand roller chain

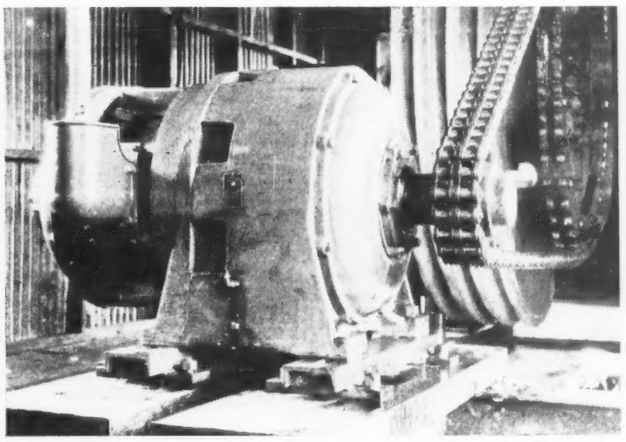


Fig. 8—Double-reduction gearmotor with 2-strand roller chain

Portable Power from Gas Turbines

Defense production may create emergency demands for temporary power. This portable power unit could supply 5000 kw to any plant in the U.S. within a few days, according to Dr J T Rettaliata, Allis-Chalmers gas-turbine engineer

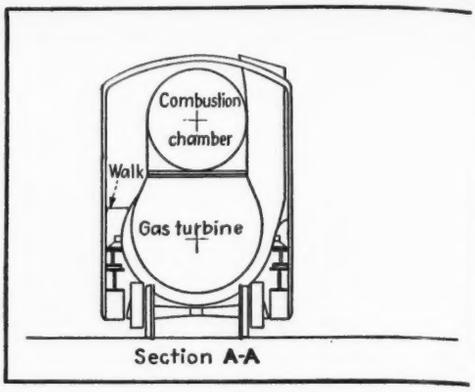


Fig. 1—Design for complete, self-contained power plant on an ordinary flatcar requires no cooling water or external auxiliaries. Fuel-oil-fired gas turbine set offers practical emergency unit.

▶ TAKING THE POWER PLANT to the load provides emergency reserve that can be used in any location for temporary tide-over of defense production. Whether occasioned by failure of overtaxed normal supply or meeting loads that grow faster than added generating equipment can be installed, power failure that interferes with production requires a restoring of supply. Speed outweighs all other items of cost or efficiency.

While the combustion gas turbine has not been applied, in this country, to direct power generation, sixteen sets are now in operation as auxiliaries to the Houdry process of refining gasoline. Experience with these units, up to five years in one case, has established their reliability and taken the gas-turbine axial-compressor out of the experimental stage. Those now in operation produce byproduct power, and one Swiss unit, designed for power generation alone, has produced over 4000 kw on test.

In its present stage of development, the gas turbine can hardly compete with either the steam turbine or diesel engine on the basis of efficiency alone. Those that have been built range up to about 2000 kw, if used for power generation, at a heat rate of about 20,000 Btu per kwhr. Existing units are designed to operate up to 1000 F as required by the refining process. Research, now in progress, indicates that designs employing temperatures up to 1500 F are practical and that efficiencies close to 12,000 Btu per kwhr are in prospect. The higher temperatures, besides improving efficiency, will result in increased capacity without material in-

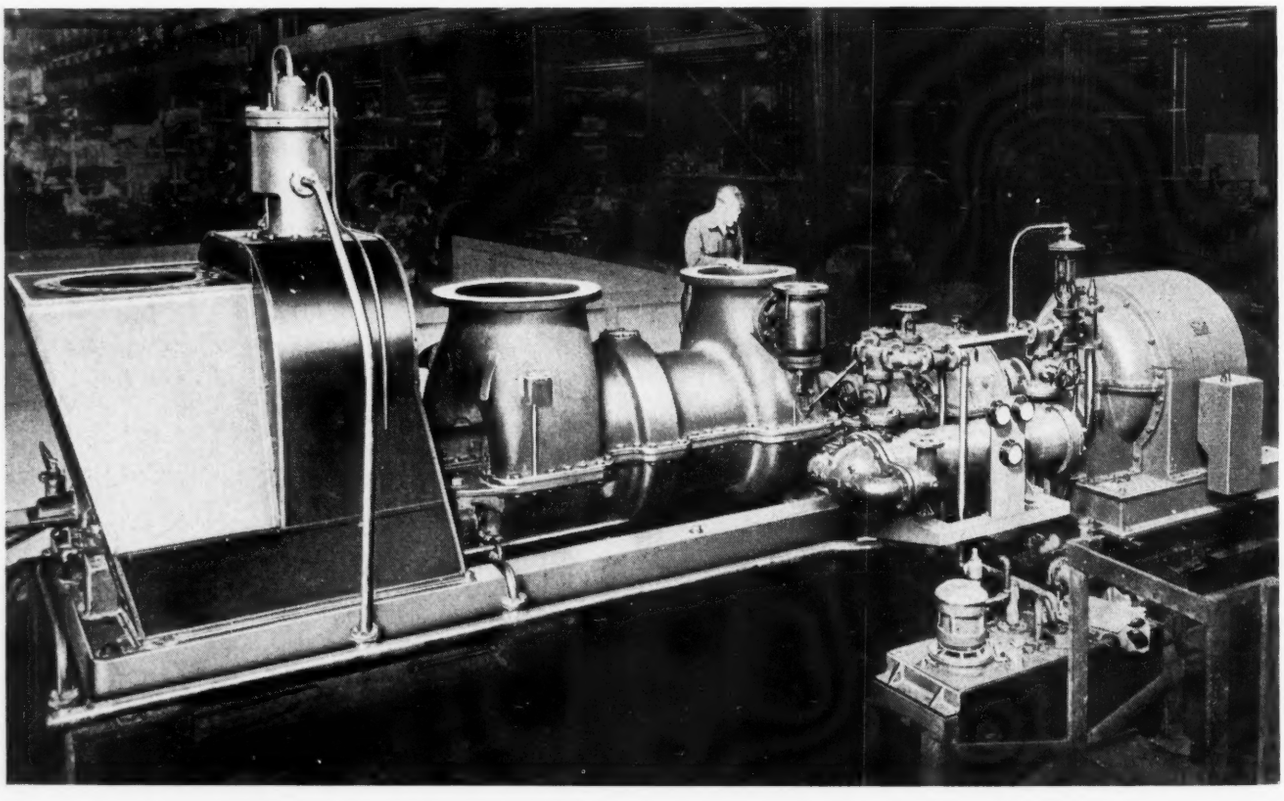
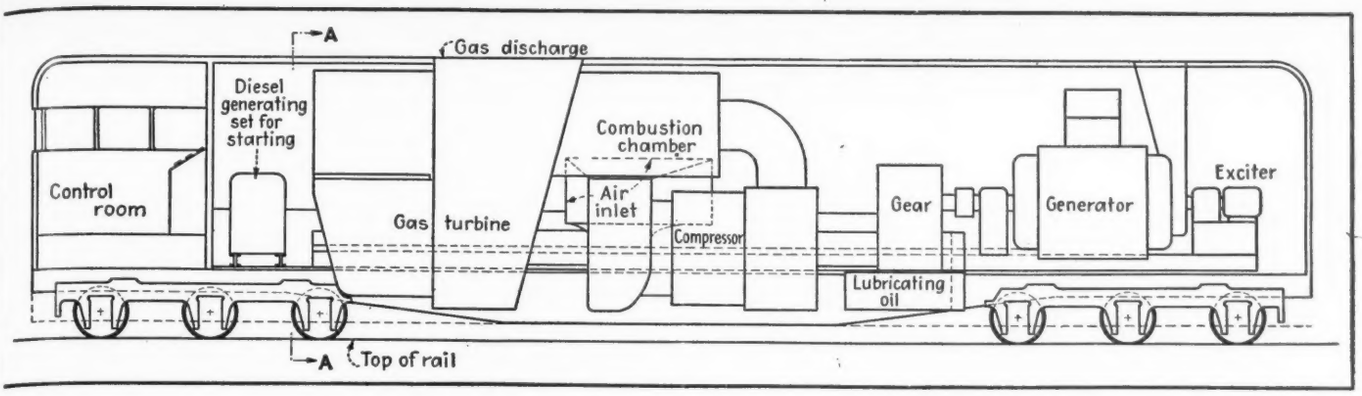


Fig. 2—One of the 16 gas-turbine axial-compressor sets now operating in this country shown on the test floor. Compactness suits portable-plant requirements



crease in weight or cost of the unit.

For the present, considering only designs and temperatures that have been proved reliable in service, the construction of a portable gas-turbine power plant on a rail car is entirely feasible. Studies of the application of gas turbines to railway locomotives assure that the unit can be made sufficiently compact and of a weight that can be carried on a single car. One such locomotive is (presumably) in service in Switzerland.

The design of an emergency portable power source presents quite different problems from those of stationary practice. First, the plant must be complete and ready to operate before an emergency arises. Second, transportation time and setting-up period should be short. Efficiency and cost become of lesser importance.

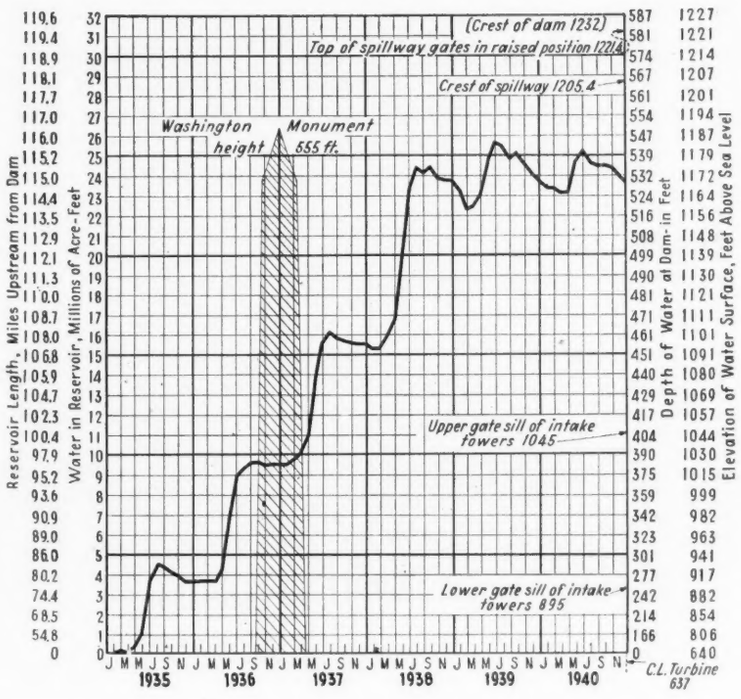
The gas turbine has several characteristics that suit the needs of portability and adaptability better than either steam turbine or diesel engine. No cooling water is required. Any fuel from bunker oil to gasoline or natural gas can be burned if provision is made beforehand. The only auxiliary required is a small diesel-electric set for starting. The gas-turbine car and one or more fuel-oil tank cars comprise a power source that needs only the connection of electrical conductors to utilize the output.

In contrast with floating power plants, such as have proposed in sizes up to 50,000 kw, a rail car could reach any part of the country in a few days. Ship-borne steam-turbine plants are limited to seacoasts or navigable waterways. Rail-car units can reach any point touched by tracks, that is, practically every industrial establishment. Floating plants must travel slowly and by devious routes, taking many weeks if the distances are great.

The unit for which a schematic design is shown in Fig. 1 would weigh less than would be possible with either diesel or steam and could be built for a lower cost per kw than the average stationary plant. A standard car carries the gas-turbine axial-compressor unit with its associated combustion chamber, a gear-driven generator with exciter, minimum essential control and switching equipment and a starting unit. A simple housing encloses the assembly. Such a power source has no feedwater-treatment or cooling-water problems, no makeup requirements or external auxiliaries and could normally be operated by one or two attendants.

✦ ✦ ✦

Six-Year Storage at Boulder Dam


(Crest of dam 1232)
Top of spillway gates in raised position 1221.4
Crest of spillway 1205.4
Washington Monument height 555 ft.
Upper gate sill of intake towers 1045
Lower gate sill of intake towers 895
C.L. Turbine 637
Reservoir Length, Miles Upstream from Dam
Water in Reservoir, Millions of Acre-Feet
Depth of Water at Dam-in Feet
Elevation of Water Surface, Feet Above Sea Level
1935
1936
1937
1938
1939
1940

► Boulder Dam on the Colorado River is probably the only one in the world that completely controls the flow of a large river. Before this dam was constructed, flow in the river below its site varied from about 1200 to 250,000 sec-ft. Low flows caused serious water shortages for irrigation and other purposes.

Since the bypass tunnels were closed in February 1935 the river has been under complete control. In June of that year nearly 4,000,000 acre-ft of water was stored back of the dam. If this water had gone down the river uncontrolled it would have produced a very destructive flood. Later in the year, river flow dropped to 5000 sec-ft above the dam, which would have caused a serious water shortage. This was prevented by releasing sufficient stored water to maintain a flow of 10,000 sec-ft as indicated on the curve.

The power plant, laid out for installation of 1,835,000 hp, will have 1,212,000 hp in operation by the end of this year. This huge power project requires water much above irrigation and other demands below the dam, and accounts for the sharp drop in the reservoir level between yearly flood periods during 1938, 1939 and 1940. However, another good water year should bring the reservoir level near the spillway crest.

THE OPERATING ENGINEER

George Edwards
Advisory Editor

Practical Aids
Maintenance Hints
Questions — Answers

Published monthly as an integral part of POWER

How to Connect DRAFT GAGES

In previous articles, W H Pugsley, The Hays Corp, explained where and how to locate draft gages. In this one, the last of the series, he shows how to hook 'em up

WHENEVER A DRAFT connection is made through a refractory setting, it is preferable to install the connection at the time the setting is built. A piece of standard 2-in. standard black iron pipe should be inserted in the wall, see Fig. 1. The inner end should extend to approximately 2 in. from the inner surface of the refractory wall, and, in the case of a furnace where flyash and high temperatures are present, the refractory wall should be flared to eliminate sharp edges, which are easily broken off and tend to fuse or burn off.

The next step is to thread the outer end of the 2-in. pipe and make it extend from 2 to 6 in. beyond the outer surface of the wall. A tee plugged on the outer end should be tightly fitted to the pipe end with the side opening vertical. The draft line can be reduced in size at this point to ½ in., and either black iron pipe or copper tubing used from here to the draft-measuring instrument.

Tubing for Connections

Copper tubing is more easily installed, fewer fittings are required and it will withstand vibrations better. Soft or semi-hard tubing is preferable to hard tubing because the former can be bent and will not break so easily.

The connection from the tee to the instrument should rise vertically not

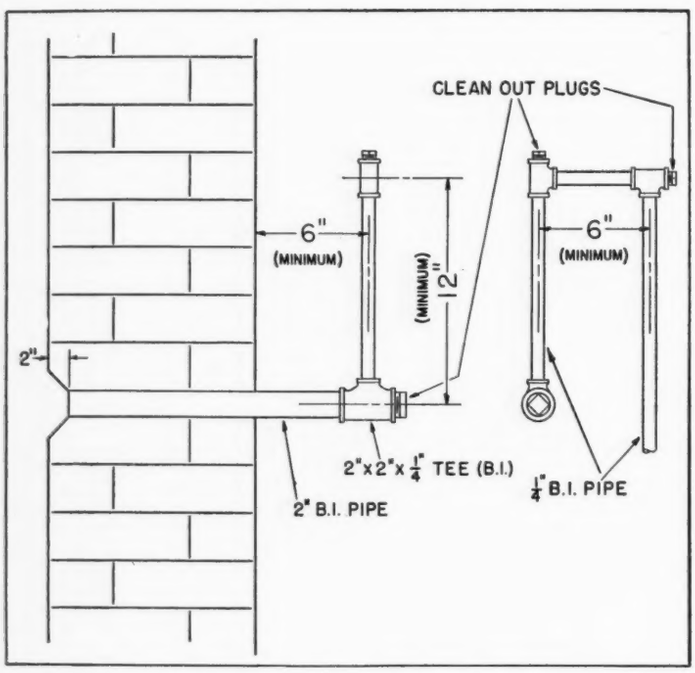


Fig. 1—Draft connection for a solid refractory setting

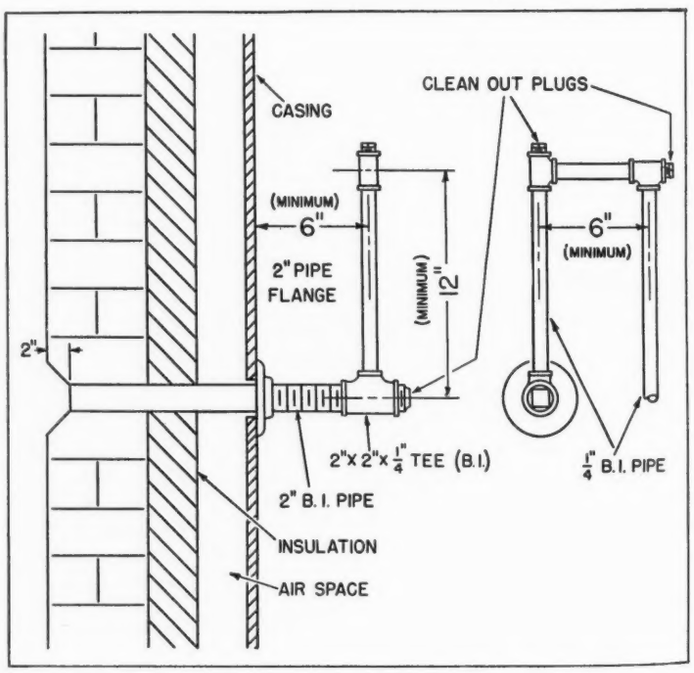


Fig. 2—Draft connection for a metal-clad, air-cooled refractory setting

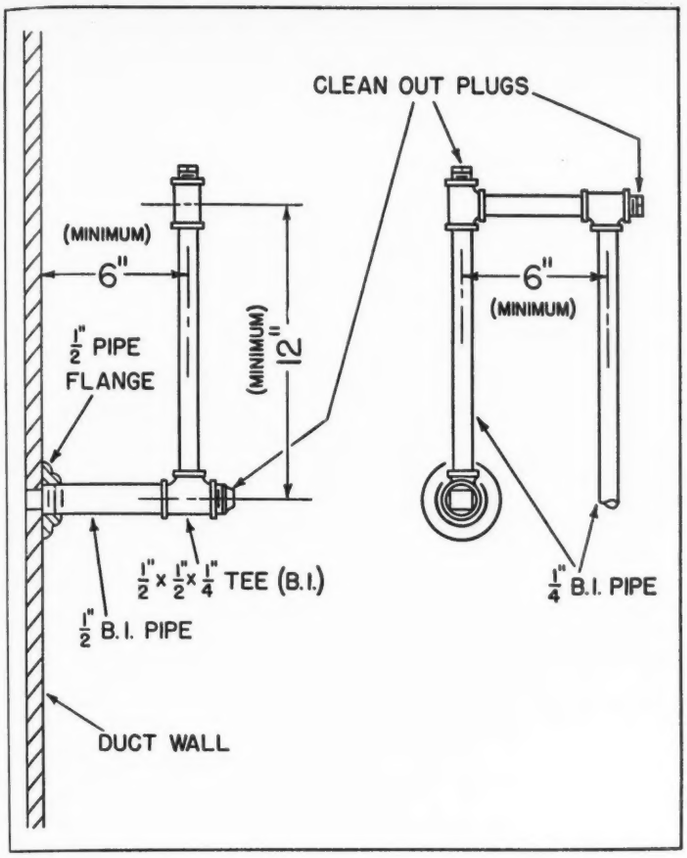


Fig. 3—For sheet-metal duct, connections are made like this

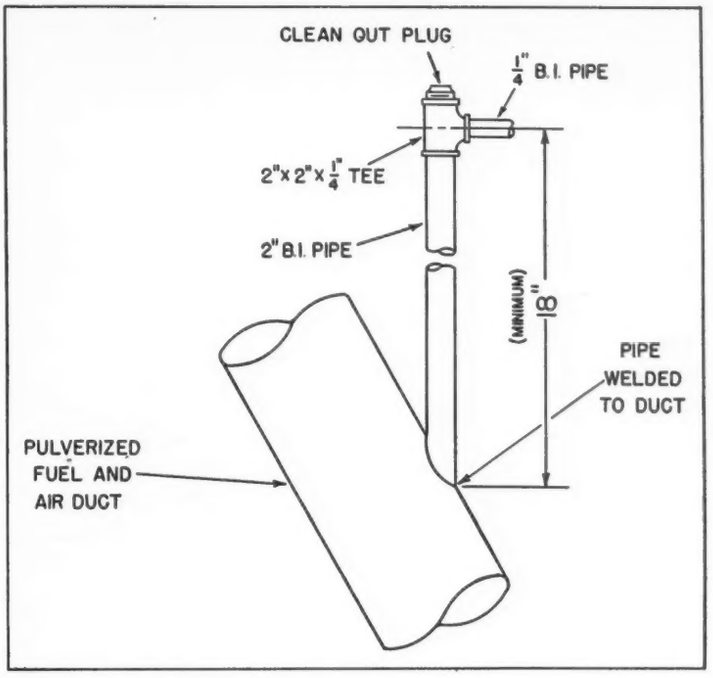


Fig. 4—For pipelines carrying air with fuel in suspension, draft connections are made like this

less than 12 in. (see Fig. 1) before running in any other direction. This eliminates the possibility of flyash or moisture filling the draft connection. The pipe plug in the tee permits removing any flyash or slag that may collect in the opening. The plug can be removed and the line blown out with air, or the slag can be pushed out with a solid rod.

Metal-Clad Refractory

The connection through a metal-clad, air-cooled refractory setting is just about the same as that for a solid setting. In addition, a hole 1 in. larger in diameter than the outside diameter of the pipe should be cut through the metal casing, see Fig. 2. This larger opening allows for movement of the refractory wall in relation to the metal casing. Generally, the refractory wall is of a supported type built to allow for expansion and contraction caused by temperature changes.

The outer end of the pipe should be threaded long enough to allow a flange to be screwed onto the pipe hand-tight against the metal casing. The 2-in. plugged tee is then screwed in place as explained before.

For connections through sheet-metal duct, a hole should be drilled or cut through the duct. Then, a pipe flange is welded or bolted to the duct into which pipe with a tee may be threaded, see Fig. 3. The hole through the duct should be the same size as the hole in the pipe. If preferred, a piece of pipe or pipe coupling may be welded directly to the duct, thus eliminating the flange entirely.

The tee should be plugged at the outer end so that the opening can be cleaned when required. Fittings are 2 in. when connections are made to duct work through which flue gas is passing, but when made to ducts through which only air is passing, ½ or ¾ in. is enough.

Pulverized-Fuel Lines

For pipes carrying air with fuel in suspension, draft connections should be made as shown in Fig. 4. Here, the connection must always be made as nearly vertical as possible, never more than 45 deg from vertical, and should be made at right angles to the direction of flow through the pipe to avoid getting a reading affected by the velocity of the air stream.

When the connection must be made to a curved section of pipe, such as the pipe between pulverizer-mill outlet and exhauster-fan inlet, it should be made in the side of the pipe at right angles to the curvature. The vertical section of 2-in. pipe should be not less than 1 ft in height and preferably 18 in. or 2 ft. The plugged tee should be used as shown and the draft connection can be reduced at the side opening of the tee to ½ or ¾ in.

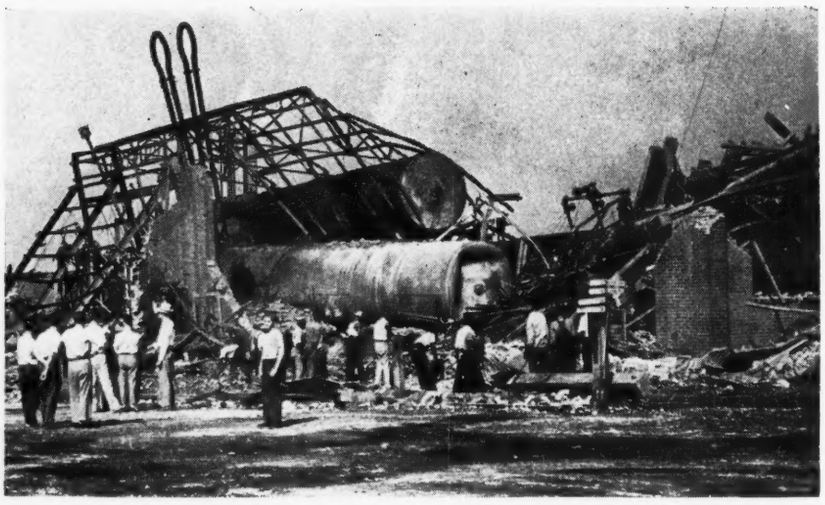
Fires and Explosions in Compressed-Air Systems

IN GENERAL, THE CHARACTERISTICS OF OILS have very little to do with air-compressor fires and explosions. Most authorities believe that some faulty condition of operation or installation must exist before fires and explosions can occur. When such conditions do exist and fires or explosions take place, it has always been found that operating temperatures have exceeded the flash-point of any oil.

Reports of explosions show that in most cases the flash-points of the oils ranged from 500 to 600 F. In diesel engines some of the most successful oils do not have flash-points above 450 F; yet the temperatures involved may be as high as 1,000 F, proving that high flash-points are not required for air-compressor oils.

Blacksburg, Va. JAMES I CLOWER

BOILER-EXPLOSION *Facts and Fallacies*



Boiler explosion (see right) caused $200,000 damage at a southern wood-preserving plant late in 1939

Where does explosive force come from? Will cold water on a red-hot crown sheet cause an explosion? What are the three basic causes of boiler explosions? R C Sermon, Boiler Inspector, gives some common-sense answers

THERE IS LITTLE ROOM for wobbly thinking where boiler explosions are concerned but a surprising number of misconceptions and fallacies persist. For some reason such notions die hard.

Why do boilers explode? Simply because the pressure exceeds the strength of some part of the boiler. Naturally, boilers are carefully designed to be amply strong to resist any pressure expected in normal service. As long as the pressure stays within reasonable limits and boiler parts retain their original strength nothing happens. With modern safety valves, properly maintained, excessive pressure causes few explosions.

Reasons for Explosions

To find the cause of most explosions we have to look for conditions that change the strength of boiler parts. Corrosion, which reduces the thickness of pressure parts and so cuts into their strength, is a common source of trouble. Excessive strains caused by buckling settings, settling of foundations, etc, may weaken parts, as may repeated stressing due to unrelieved expansion.

A whole host of troubles end up in overheating of boiler parts. Scale formation may reduce heat transfer to a point where metal temperatures become excessive; steam blanketing in tubes, lack of positive circulation, and oil films on metal surfaces may produce the same result. Most sensational cause of overheating is low water, probably blamed for more explosions than any other cause. Failure usually follows these conditions because the strength of metals falls off sharply at high temperatures.

Where does the terrific explosive force come from? It lies in the hot water stored in the boiler. This water is at boiler pressure and close to saturation temperature for that pressure. Thus it contains far more energy than water saturated at atmospheric pressure. If the boiler fails, this stored water is suddenly exposed to atmospheric pressure instead of boiler pressure and a terrific expansion occurs almost instantaneously. Calculations of this force explain how exploding drums travel tremendous distances in some cases and how even a low-pressure-heating-boiler explosion can wreak unbelievable havoc.

Most persistent fallacy of all is the belief that injecting water into a boiler after water has gone low is a fatal mistake bound to lead to an explosion. A little thinking will show that this is not so and cannot be so, because if the entire boiler became red hot there still wouldn't be enough heat available to cause an explosion by sudden generation of steam.

To prove this point, a large railroad ran an old locomotive onto a side track, planning to fire the boiler until the steam was high, then blow it out to expose the crown sheet and allow it to become red hot. Cold water was to be forced into the boiler from a fire engine located a safe distance away. The first attempt failed because the old boiler exploded at 200 lb pressure while still full of water. Repeating the test on another boiler worked out successfully and the only effect of chilling a red-hot crown sheet with cold water was some leaky seams.

The practical conclusion to be drawn from this is not to let the water get low, but if it does, add water quickly. This applies to all steel boilers. In the case of cast-iron boilers, injection of cold water on hot surfaces is likely to cause fracture, and so is not recommended.

CORRECTION

The article "Piping and Control for Unit Heaters" (page 93, February POWER) made the following statement concerning traps for heaters on open 2-pipe gravity and vacuum systems: "Two trapping functions are involved in either system: (1) removal of condensate without loss of steam, and (2) removal of air without loss of steam. These jobs can be performed by a thermostatic trap, by a combination float-and-thermostatic trap or by a conventional float or bucket trap for condensate removal and a thermostatic bypass for air removal."

Mention should have been made of the fact that inverted-bucket traps, with ordinary or thermostatic air vent, will handle both parts of the job without need for a thermostatic bypass.

Home-Made Condensate Meter

A reader has asked for comments on this simple scheme for measuring condensate returns — can you find anything wrong with it?

WHAT DO POWER READERS THINK of the idea for measuring condensate returns illustrated by the accompanying sketch? I propose to measure the returns by a receiving tank equipped at the bottom with a large and a small orifice. The large orifice discharges to the sump, the small orifice to a measuring tank.

It seems obvious to me that the small orifice would always discharge a fixed fraction of the flow through the large orifice, in the ratio of the areas of the openings, because at every moment the head on the two orifices would be the same. The only limitations are that the small orifice must be small enough to prevent the measuring tank overflowing in a day's run, and the large orifice must pass enough water to prevent the big tank from overflowing.

Suppose the diameter of the big orifice is 1.0 in. and that of the small one is 0.1 in. Then the area ratio will be 100 to 1 (area varies as the square of the diameter). If both orifices are of the same shape (knife edge with flat side on top), the two discharges will be in the same proportion as the areas, 100 to 1.

How It Works

Suppose we start with the small measuring tank empty. At the end of the day we read the scale on the measuring tank and then empty it into the sump by the valve shown. Let's say the amount of water collected in the measuring tank was 260 lb. Then the discharge of the large orifice will be $100 \times 260 = 26{,}000$ lb and the total flow of returns would be $26{,}000 + 260$ or 26,260 lb. To avoid even this easy calculation, it would be a simple matter to graduate the scale on the measuring tank to read 101 times the actual amount of water collected in the small tank.

Before signing off, let me list the only limitations I can see to this method:

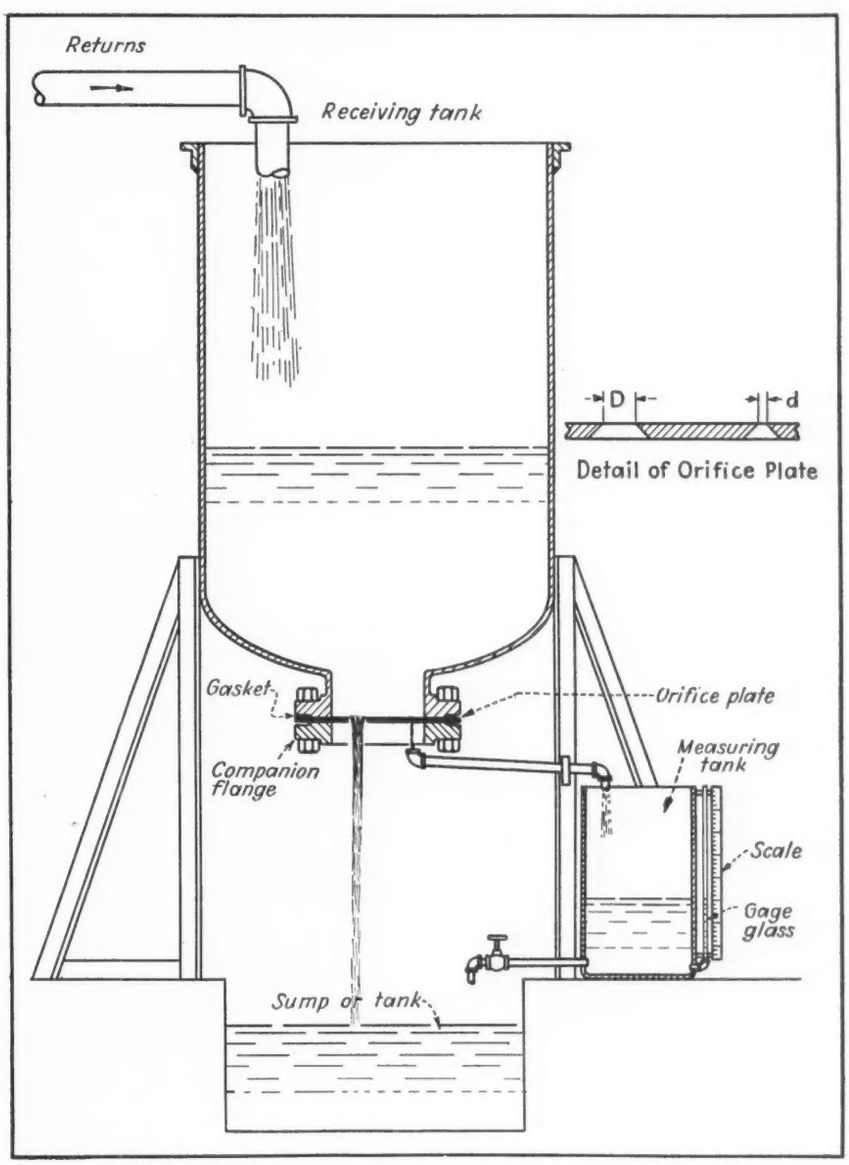
1. It is practical only where there is a free discharge. I can't figure out any way to use this principle to measure flow against a backpressure.

2. Returns should come back fairly steadily, at least enough so that the tank won't go dry at frequent intervals. The orifices would not be very accurate when the tank was practically empty.

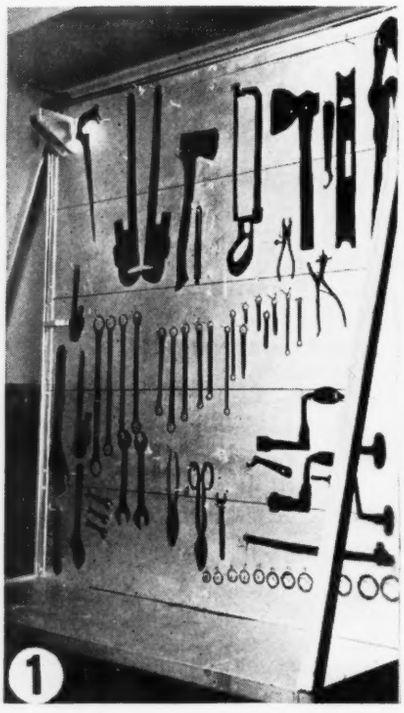
3. The layout of the plant must permit locating the measuring tank a considerable distance below the highest level at which returns will flow back.

4. Extreme care must be used in measuring the contents of the small tank, as any error is multiplied by 101, making a considerable difference.

Perhaps POWER readers will tell me what they think of this setup or suggest better methods. They might also have some ideas on other ways to use the same principle of water measurement. I'm really very modest about this idea and can take it, so let the comments fly where they will.—RNG.



PRACTICAL AIDS TO OPERATION



How to Keep From Losing Tools

TOOLS BECOME MISLAID or are accidentally left where last used and are not missed until they are needed for the next job. To make it easy to keep track of tools, we painted the design of each one on the board, Fig. 1, where it is supposed to be stored when not in use.

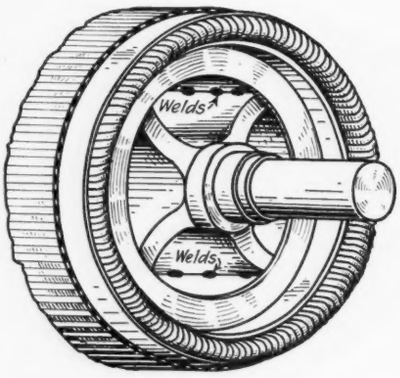
Fig. 2 shows the same board with all the tools in place, with the exception of a Stillson wrench, a hacksaw and two end wrenches. Absence of the tools is easily detected. Now that workmen know that tools missing from the board are very likely to be asked about, they take care to return them to their proper places.

Kearny, Neb. W K KNOLL, JR

Armature Core Welded to Spider

WELDING IS THE ANSWER to many maintenance men's prayers when they are looking for a way out of a tough situation. We found it so when the core of one of our dc fan motors came loose on its spider. The spider and commutator remained tight on the shaft so that the only movement due to the looseness was between the armature-core and the spider.

This caused noisy operation and a slight bending action on the armature leads where they connected to the commutator. It looked as if we had an expensive job on our hands to rebuild the armature until we tried welding.



We welded the core to the spider by having a welder deposit light sections of a single electric welding bead in the corners formed by the ends of the spider arms and the inside of the core, as in the figure. The beads were made in short sections that filled about 50% of the total length of the corners. The job was done slowly and carefully so as not to raise the core-temperature to where it might damage the coil insulation or cause excessive stresses in the armature structure. The job required only about two hours to complete and after the fan had been in operation several months the core showed no signs of looseness on the spider.

New York, N. Y. THOMAS WOOD
Chief Engineer, Hotel Commodore

Avoid Wrenches for Valve Operation

INDISCRIMINATE USE OF WRENCHES or bars to operate valves is rightly condemned by all safety-minded engineers. If valves are properly maintained and operated, conditions should not develop that call for excessive leverage to open or close them.

Attempting to prevent valves from leaking by applying excessive downward pressure on their stems in hazardous, since there is always danger of the thrust breaking the bonnet on its joint. Similarly, where a valve cannot be operated with its handwheel at any position between open and closed, something has gone wrong that cannot be remedied by excessive leverage. In most cases this trouble can be corrected by loosening and lubricating the packing or by cleaning accumulations of dirt and corrosion from the valve stem. If these remedies fail, the valve should be removed and repaired or replaced.

Necessity of having to force valves off their seats or to start them closing can be avoided by backing them off slightly from either extreme position after each operation. This prevents jamming of the valve-stem threads due to expansion or contraction of the valve parts and permits movement of the wheel before the stem-threads engage.

If it is necessary to use added leverage on a valve other than that afforded by the handwheel it should be applied with extreme care and in a way that will not produce excessive bending

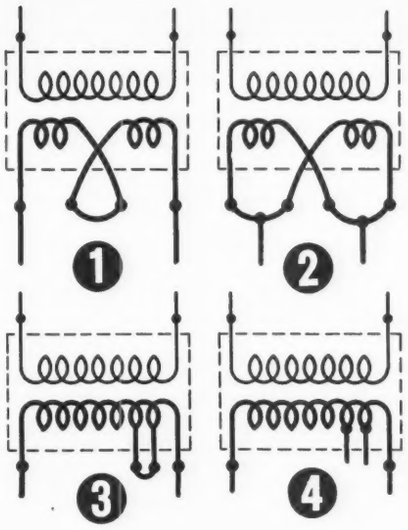
stresses in the handwheel. Special valve wrenches can be easily made for this purpose that properly fit the valve-wheel.

Roanoke, Va. S H COLEMAN

Re-Connection Cures Transformer Trouble

DISTRIBUTION TRANSFORMERS NORMALLY HAVE two high-voltage and four low-voltage leads brought to the outside of their tanks, see Figs. 1 and 2. The two inside low-voltage leads are crossed inside the tank before they are brought out. This permits connecting the two halves of the winding in series, Fig. 1, for full secondary voltage, and in parallel, Fig. 2, for half secondary volts.

Two transformers were purchased second-hand and installed, but when they were connected to the line the fuses blew in a way that indicated a short-circuit in the transformers. A service man was then called from the manufacturer who found that the transformers



were of a special design with three leads brought out at one end of the winding, Figs. 3 and 4, for voltage adjustment. The electrician who wired the transformers assumed that they were standard and connected the inside leads together, Fig. 3, to obtain full secondary voltage. In doing this he short-circuited a section of the winding. The trouble was corrected by leaving the center leads open, Fig. 4, and insulating them.

Plainfield, N. J. H W HODGSON

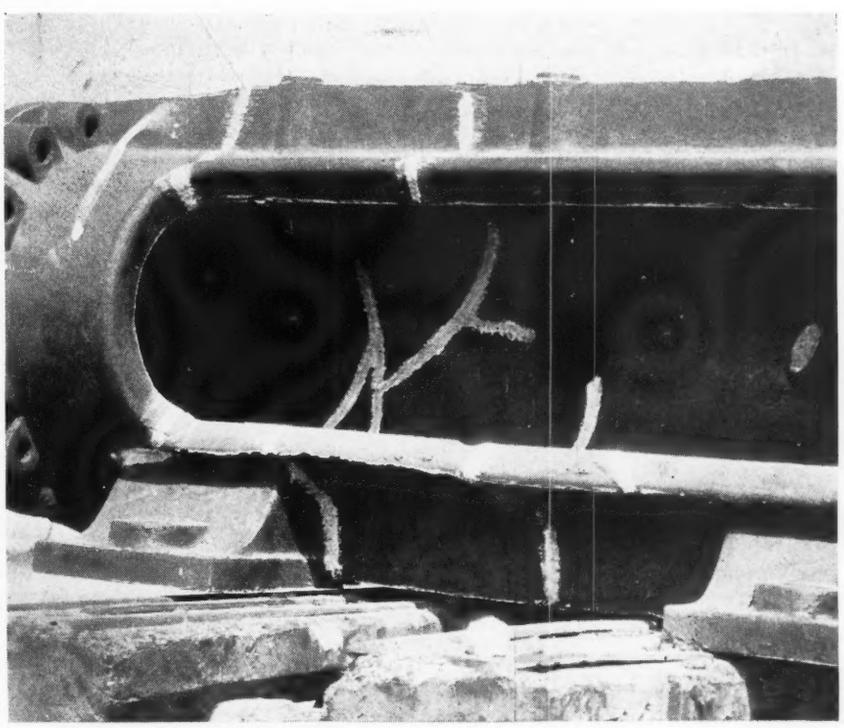
Troubles on 3-Wire Balancer Sets

AS A TROUBLE SHOOTER I have found that balancer sets, used with 2-wire direct-current generators to obtain 3-wire systems, are very sensitive machines. Minor defects that might not cause trouble on a motor or generator will be serious on balancer sets. Some of the causes of troubles on these machines are: units not level, slightly worn bearings, brushes set slightly off neutral of one or both machines, and a slight roughness of the commutator on one or both machines. I have records of 21 cases of faulty operation of balancer sets due to rough commutators.

Trenton, N. J. R D CUMMINGS

Welding Repairs Wrecked Engine

WHEN THE GERMANS ENTERED Alderney last year they found the best welding job ever done in the Channel Islands, on the frame of a 750-hp compound condensing locomobile engine. The engine on this type of unit is mounted above the boiler. One day the connecting rod became disconnected from the crosshead in the high-pressure side of the engine. As a result, the piston rod was curled around the stuffing box, the flange on the head end of the low-pressure cylinder and valve chest was cracked, the frame and cross-head shoes on both sides of the engine were also badly broken, some pieces being only about 1 ft square.



The insurance company would not consider a repair job and it would have taken from five to six months to get new parts and install them. No other source of power was available, so the engineer on the job decided that a repair was worth trying.

First, the engine was taken apart, the broken pieces assembled and held together by light tack welds and tap bolts. When it found that the broken parts could be assembled, the cracks were veed for the welders. It was believed that the welding would not stand the loads without some additional support, so while preparations were being made for the welders, templates were made for stays, designed to stiffen the frames containing the cross heads.

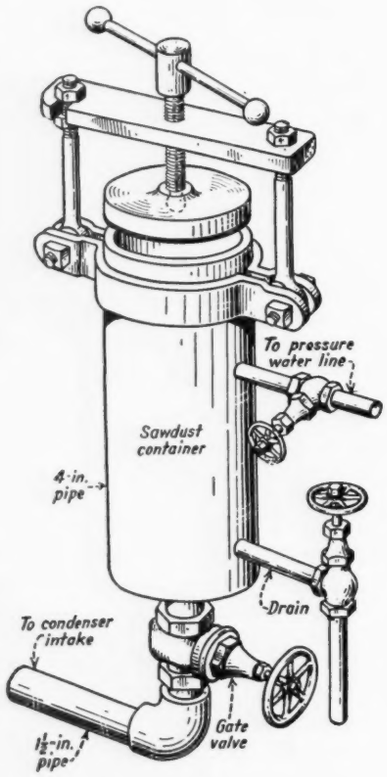
These stays were designed to take both longitudinal and transverse loads. They were made of cast steel and weighed about 3 tons. When the stays were ready they were installed onto the assembled parts of the frame to hold them tightly in place while the welding was done.

After the welding was completed all open space between the stays and the castings were filled with iron cement, which, in effect, made the frame and stays one solid casting. The cracks

around the low-pressure cylinder flanges were welded and strengthened by long bolts running through the head-and crank-end flanges.

When all repair work was completed and the engine assembled and carefully aligned it required very little doctoring up except some high spots on the cross-head guides, which were taken down with carborundum sticks. The job was done in three weeks with two crews working double shifts and operated satisfactorily for over 3 years until the engine frame was replaced. The white lines on the photo give a general idea of how the frame was broken.

Coventry, England F L BERRY



Stops Condenser Leaks With Sawdust

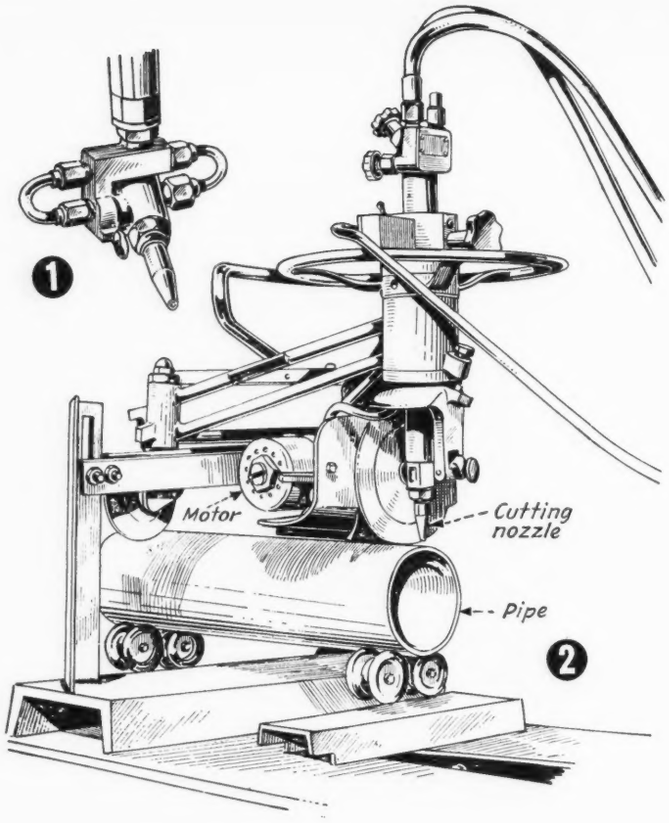
TO SUPPLY THE EVER-INCREASING DEMANDS for power, many operating engineers will be called upon to keep equipment in service when it should be shut down for overhauling. It may help in some cases to know of an old marine engineer's stunt of using sawdust for stopping leaks in a condenser.

On board ship the condensate is usually tested every hour and if there is any indication of salt, fine sawdust is pumped into the condenser circulating water before it enters the condenser shell. The vacuum on the steam side of the tubes causes the sawdust to be drawn into the small leaks and stops them. By administering a shot of fine sawdust whenever the condensate shows signs of salinity it is possible to operate for several months before it becomes necessary to open the condenser for replacing or plugging tubes.

The sawdust may be fed into the condenser in several ways. One is to use a pump with its discharge connected between the circulating-water pump and condenser. The sawdust is then fed into the suction of the auxiliary pump. The figure shows a sawdust injector easily made with a piece of 4-in. pipe as its body.

The bottom of the pipe is closed by a steel disk welded into place. A 1½-in. nipple is tapped into this disk for a 1½-in. gate valve and connection into the condenser intake line. A 1-in. drain and a pressure line are tapped into the side of the sawdust container. A pressure cover connects to the top of the container, which is arranged so that it can be swung to one side when the container is being filled.

To inject the sawdust, first close the gate, drain valves and pressure-water valves. Then open the cover and fill the container about ⅓ full of water, after which fill it with sawdust and tighten



Beveling Pipe With Portable Machine

HERE IS A SIMPLE DEVICE that facilitates the cutting and beveling of pipe with a standard portable oxyacetylene cutting machine. It consists of two channel-iron sections, one light and one heavy, mounting ball-bearing rollers for supporting the pipe, Fig. 2. The heavier channel-iron section mounts vertical angle-iron columns and strap-iron cross members between which the rear wheels of the cutting machine are clamped. Slots in the vertical supporting columns permit adjustment of the rig for various pipe diameters.

In the drawing the cutting machine and pipe are positioned for making a square cut. Bevels are made by substituting a bevel-cutting nozzle, Fig. 1, for the standard cutting nozzle. Since the cutting machine is rigidly clamped in place, motive power supplied by its electric motor is transmitted through the drive-wheel to the pipe, rotating it on the ball-bearing rollers. Speed of pipe rotation is governed by adjustment of the motor speed control, and smooth, even cuts can be made without difficulty.

HOLFORD THORNS and JAMES MARJIE, *Weyl-Zuckerman & Co, Stockton, Cal.*

the cover. Open the gate valve and then open the pressure-water valve to force the sawdust slowly into the condenser-circulating-water inlet. If one container full of sawdust does not do the trick try another. It is important that water be put into the container before the sawdust to prevent packing around the outlet pipe connection.

New York, N. Y. S M Elonka

Hole in Check Valve Prevents Freezing

The garage connected with our plant is heated when required by unit heaters that drain into a condensate tank, as in Fig. 2. From this tank the condensate is pumped back to the boiler room by a float-controlled motor-driven pump in the tank. Sometimes, during very cold weather, it got cold enough around the condensate tank to freeze the water in the pipe. Then, when the pump started again, it could not empty the tank until the pipe was thawed out.

As the purpose of the check valve was to prevent water flowing back out of the discharge pipe fast enough to create a syphon when the pump stopped, I drilled a ⅛-in. hole in the valve disk, into the condensate tank, without syphoning water from the receiver tank in the boiler room. Since drilling the hole in the valve disk we have had no trouble with the pipe freezing.

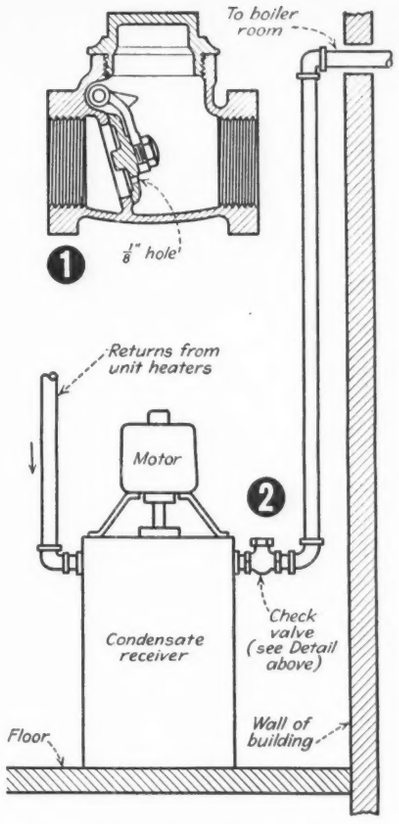


Fig. 1. This hole permits the water in the discharge line to drain slowly back

Englewood, N. J. R Boettinger

Wind Overloads Exhaust-Fan Motor

A 36-in. fan was installed in the window of an electroplating plant to exhaust dust and fumes. This fan motor burned out on two occasions. These failures were apparently due to overload, but an inspection failed to indicate any abnormal conditions.

Then, one day, a fuse blew and an engineering-service company's troubleman was called. When he arrived he found the fan running in reverse direction. This was caused by a strong east wind that was then blowing. It was found that under these conditions the fan motor could be sufficiently overloaded to burn out its windings. Installing a short duct extending upward at a 45-deg angle from the fan discharge prevented further trouble from overloads of the motor.

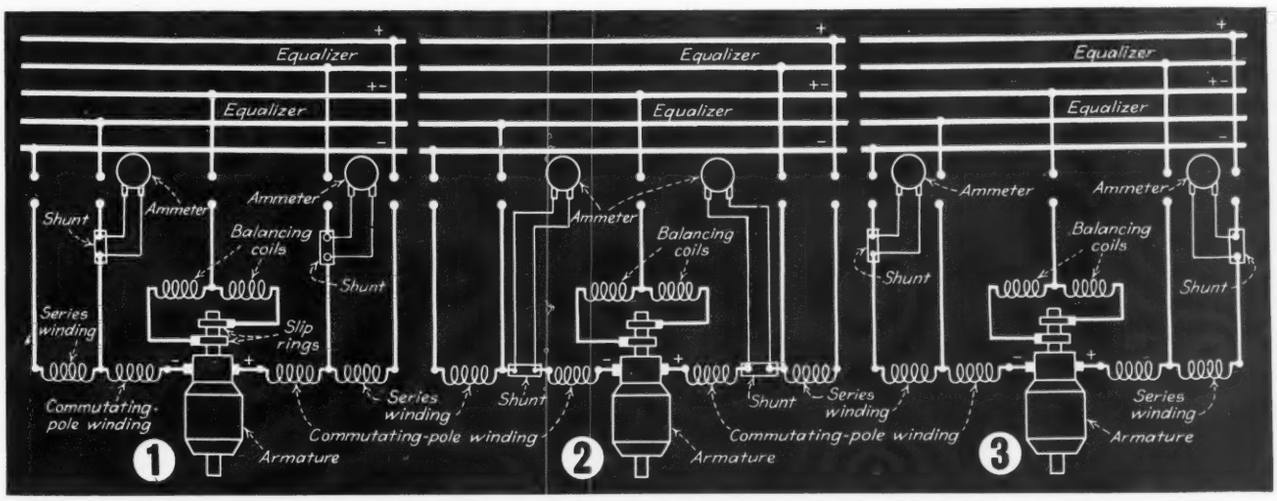
Plainfield, N. J. H W Hodgson

Ammeter Connections on 3-Wire Generators

A 3-wire direct-current generator was installed by the purchaser. After the machine was put into service the manufacturer got a telephone call to the effect that long before the generator was half loaded the turbine began to slow down and act as if overloaded. A service man sent out to the job found the ammeters connected into the equalizer leads, as in Fig. 1. In this position they indicated only the current flowing in the equalizer leads.

To give a true reading of the ampere load on a 3-wire generator the ammeters must be connected on the armature side of the equalizer connections, see Fig. 2. On this particular job the generator was a considerable distance from the switchboard so it was decided to connect the ammeters into the leads from the series fields to the switchboard, Fig. 3. With the ammeters connected this way they indicated the total current minus that in the equalizers. When the new machine had been properly adjusted it was found that the current in the equalizer was normally quite small. Therefore the ammeter readings were a fairly close guide to generator load.

Philadelphia, Pa. S O Smith



READERS' PROBLEMS

Questions from Our Readers

Removing Water from Fuel Oil

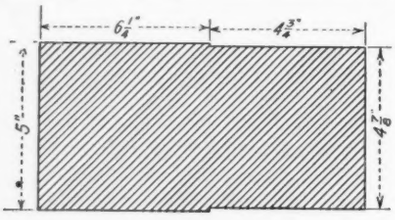
Question 1

IN OUR PLANT, *we are having trouble with removal of water from our fuel oil. The oil in question is approximately a No. 5. The water content is excessive, and for some reason unknown to me the water does not seem to settle out of the oil at all. A discussion as to the reasons for this brought up the point whether or not any substance could be introduced into the tanks that would precipitate the water or which could be used with heat to hurry up the removal process. I would appreciate hearing from* POWER *readers who have successfully solved similar problems.*—HHP.

Loose Crank Pin

Question 2

THE CORLISS ENGINE *I am running is 18x36 and runs 95 rpm at 140 lb pressure. It has pulled the crank pin loose twice in the*



disk. Both times the pin has been shrunk in the disk. The diagram shows dimensions of the pin. I am wondering if any power engineers can tell me what is causing this difficulty.—AW.

SUITABLE ANSWERS from readers will be paid for if space is available for publication. Answers accompanied by practical drawings or photographs will command additional pay.

Will Pipe Cleaning Pay?

Answers to Feb Question 1

The Question

IN OUR WATER PLANT, *we have two deep-wells equipped to pump into an 8-in. line 2850 ft long, with a 6-in. line from each well pump, 320 ft long. The sketch shows the general arrangement. These lines are scaled up badly, especially the 8-in.; it has an area about equal to that of a 5½-in. pipe. The question is, will there be a pay-out if we spend approximately $700 cleaning these lines, and how long will it take?*

Under present operation, which is fully automatic, No. 1 pump starts and pumps at a rate of 230 gpm for the first hour, then runs for about 48 hours at 208 gpm and if continued in service for several days without stopping drops down to about 200 gpm and stays there for 6 or 7 days' run. The total head is 268 ft. When No. 1 pump drops under 228 gpm, No. 2 comes on until water level in the filters reaches a predetermined level, and then shuts down. If the booster should run out of water at the clear well, it stops and when the deep-well pumps fill the clear well, the booster starts. Should the storage tank, 7¼ miles away, fill, the booster stops.

When pumping alone, at 220 gpm, No. 1 pump uses 22 hp, and when No. 2 is running the total input is 34 hp. Our electric power rate is based on a guaranteed load of 100 hp and the energy charge is $.012 per kwhr. At this time of the year, No. 1 pump furnishes all the water we need and from the end of March to the middle of October, No. 2 pump cuts in for about 25% of the time, on the average.—FTW.

How to Determine If It Will Pay

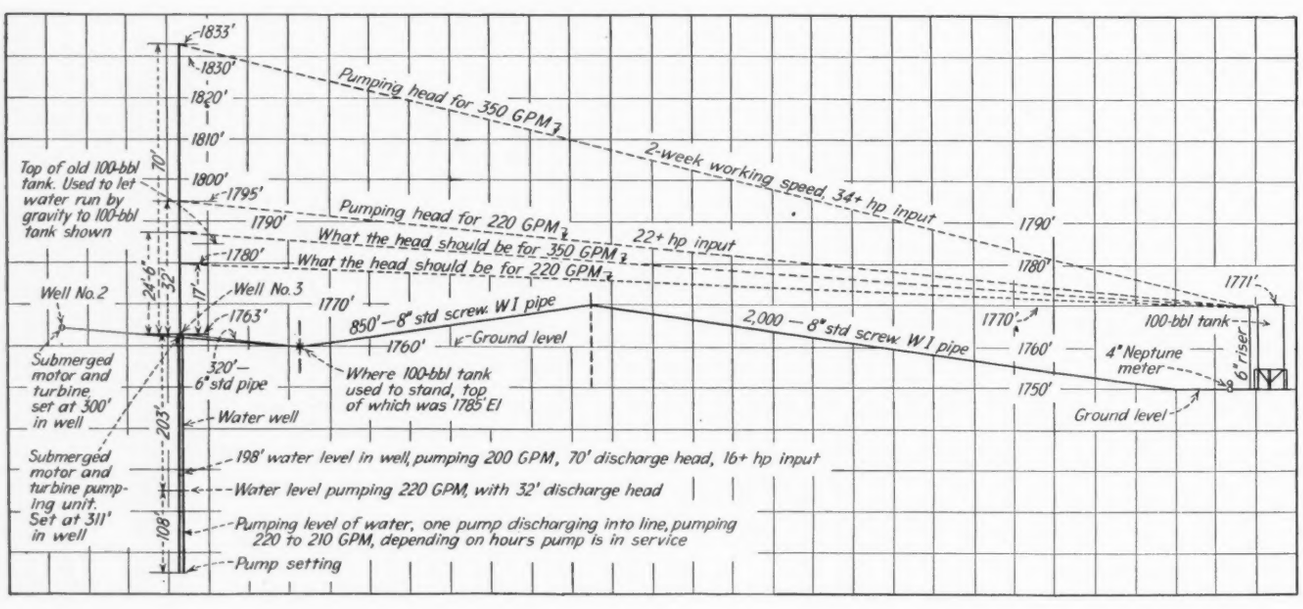
WITHOUT ALL THE FACTS, an accurate estimate of the savings from cleaning the pipe cannot be made. Approximations, however, can be set down that will give a general idea of what can be expected.

FTW says that the 8-in. line has accumulated a coating on the inside that has reduced its diameter to 5.5 in. If we assume an average pumping rate of 225 gpm, we have 2850 ft of 5.5-in. pipe with 225 gpm flowing through it. According to the tables for head loss in pipelines, 225 gpm flowing through a 6-in. line will cause a head loss of 0.74 ft per 100 ft of pipe, and in a 5-in. pipe the loss will be 1.86 ft.

Then, in a 5.5-in. line we can assume that the head loss will be $(0.74+1.86) \div 2=1.3$ ft per 100 ft of pipe. This gives a total head loss in 2850 ft of pipe of $(2850 \div 100) \times 1.3=37.05$ ft, say 37 ft.

If the pipe were clean, the head loss per 100 ft at 225 gpm flow would drop to 0.18 ft per 100 ft of pipe, or a total of $(2850 \div 100) \times 0.18=5.13$, say 5 ft. The difference in head losses under the two conditions is $37-5=32$ ft. In other words, the pump would be working against 32 ft less head after the pipe is cleaned.

The horsepower necessary to pump water equals the flow in gpm times the head in feet divided by 3690 times the efficiency. If we assume a pump efficiency of 0.70, then the power increase is $(225 \times 32) \div$



$(3690 \times 0.70) = 2.6$ hp. This is equivalent to $2.6 \times 0.746 = 1.95$, say 2 kw extra required to drive the pump for each hour it is in operation.

If the pump operates an average of 8000 hours per year, then the increase in power required, caused by the poor condition of the pipe, is $8000 \times 2 = 16{,}000$ kwhr. At 1.2 cents per kwhr, the cost is just about $200 per year, which is the yearly saving to be expected from cleaning the 8-in. line. If the cleaning costs $700, it will take 3½ years to pay off the cost.

Other benefits may be expected from cleaning the line, one of these being improved pump efficiency. If the pump is working at its best efficiency when the pipe is clean, then when inside pipe diameter is reduced to 5.5 in., the pump will operate at lower efficiency because of increased head.

FTW is also reaching the critical point in the pipe where the head will begin to increase very rapidly and the flow will decrease proportionately. For example, if the inside diameter of the 8-in. pipe is reduced to 5 in., the head loss will amount to 1.86 ft per 100 ft of pipe at 225 gpm. The total head loss will be $(2850 \div 100) \times 1.86 = 53$ ft. If the inside diameter should drop to 4 in., the head loss at 225 gpm will be $(2850 \div 100) \times 5.45 = 155$ ft.

Of course, these head losses cannot result, because the increased head will lower the flow from the pump far below what it is now, and may even cause the pump to stop. At best the pump will operate at very low efficiency. Furthermore, adding another pump will not do any good. If the pipeline is in such condition that it cannot take the discharge from one pump, it cannot take two. All of these conditions indicate strongly that the pipeline should be cleaned.

Flushing, N. Y. GEORGE J ALLEN

Probable Answer Is to Clean Pipe

FTW'S PROBLEM primarily resolves itself into collecting the essential information for correct solution. No doubt there are many opinions as to what this may be. My selection is shown below:

Data:

Difference in head when pumping 220 gpm with present pipe and clean pipe = 15 ft.
Difference in head when pumping 350 gpm with present pipe and clean pipe = 45.5 ft.
Pump efficiency (assumed) = 68%
Motor efficiency (assumed) = 90%
Number of days October 16 to March 31 (inclusive) = 167
Number of days April 1 to October 15 (inclusive) = 198
Cost per kwhr = $0.012
Between April 1 and October 15 the pumping rate is 350 gpm for 25% of the time

Solution: From October 16 to March 31

Extra motor input

$$= \frac{(\text{gpm})\ (\text{hd in ft})\ (0.4334)\ (8.34)\ (0.746)}{(3300)\ (\text{Pump eff})\ (\text{Motor eff})}$$

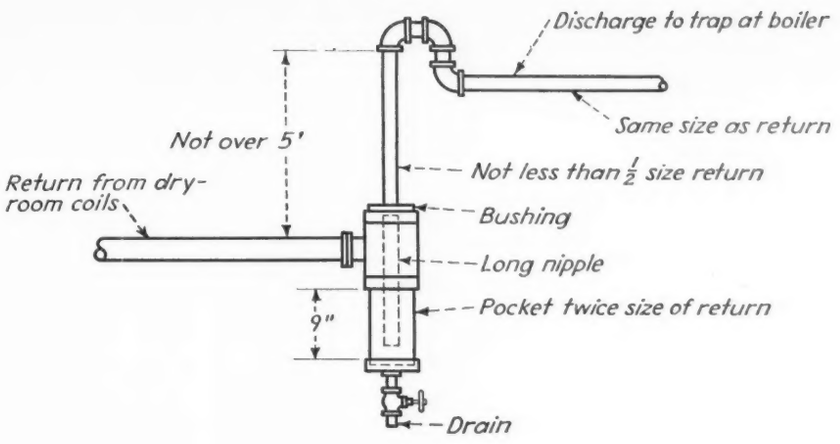
$$= \frac{220 \times 15 \times 0.4334 \times 8.34 \times 0.746}{3300 \times 0.68 \times 0.90}$$

$$= 0.44 \text{ kw}$$

Extra kwhrs used = $0.44 \times 24 \times 167 = 1770$

From April 1 to October 15

Extra motor input =



$$= \frac{[(3)\ (\text{gpm})\ (\text{hd in ft}) + (\text{gpm})\ (\text{hd in ft})] \times (0.4334)\ (8.34)\ (0.746)}{(3300)\ (\text{Pump eff})\ (\text{Motor eff})\ (4)}$$

$$= \frac{[3 \times 220 \times 15 + 350 \times 45.5] \times 0.4334 \times 8.34 \times 0.746}{3300 \times 0.68 \times 0.90 \times 4}$$

$$= 0.862 \text{ kw}$$

Extra kwhrs used = $0.862 \times 24 \times 198 = 4130$
Total extra kwhrs used = $1770 + 4130 = 5900$
Total extra cost per year with present pipe = $5900 \times 0.012 = \$70.80$

$$\text{Pay out} = \frac{\$700}{\$70.80} = 9.9 \text{ years}$$

Several things should be noted about the above solution. Pump and motor efficiencies assumed are for new equipment. As the efficiencies of these decrease, the extra cost for power will increase. Thus, if pump efficiency is only 50% and motor efficiency only 80%, the extra cost is $108 instead of $70.80. Further reduction in pipe diameter due to more scale-up will also increase the yearly extra cost, because of the resulting increase in velocity head and friction head.

Wilmington, Del. J M TUFFT

Returning Condensate

Answers to Feb Question 2

The Question

IN A RECENT EXAMINATION, *this question was asked: "A dry room is quite a bit lower than the boiler room of a laundry plant. How can the condensate be returned to the boiler with the use of only one trap, set correctly on the boiler setting. In other words, the condensate from the dry-room coils has to reach the trap on the boiler without help of other traps or a pump." Perhaps readers of* POWER *can give some suggestions as to a hookup.*—NTG

Short and Sweet

MY ANSWER to NTG's problem is short and sweet—see sketch above. That's all.

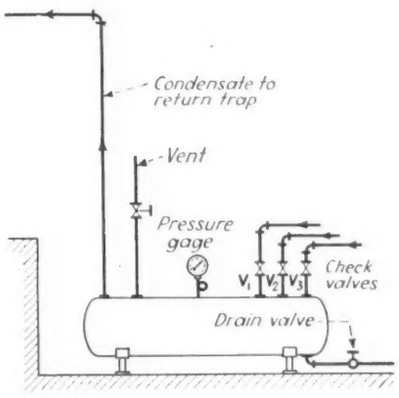
Houston, Texas L R SMITH

A Simple Hookup

MY SUGGESTION is the hookup shown in the sketch. The condensate from the dryers is piped up to a receiver tank. Check valves must be used in each line as shown to prevent the condensate from backing up into the lines.

If a vent is fitted, it must be provided with a shutoff valve, as the tank must be kept under pressure high enough to insure condensate reaching the trap. A pressure of 5 lb per sq in. will force water to a height of about 10 ft; 7 lb per sq in. will force water about 15 ft. The trap should be not less than 3 ft above the water level in the boiler.

S Vineland, N. J. T DE ROSA

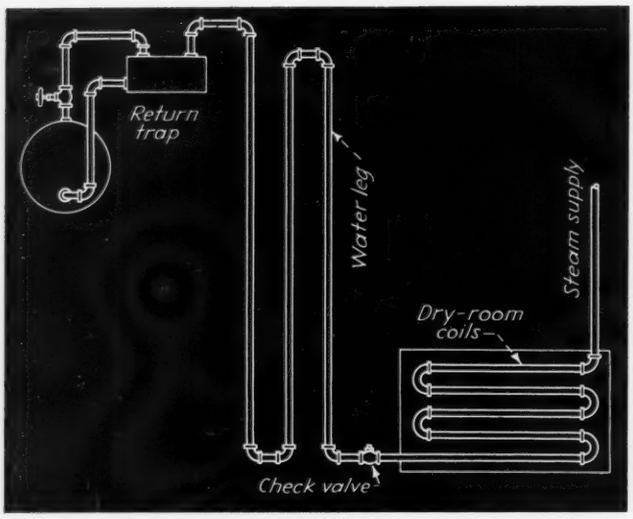


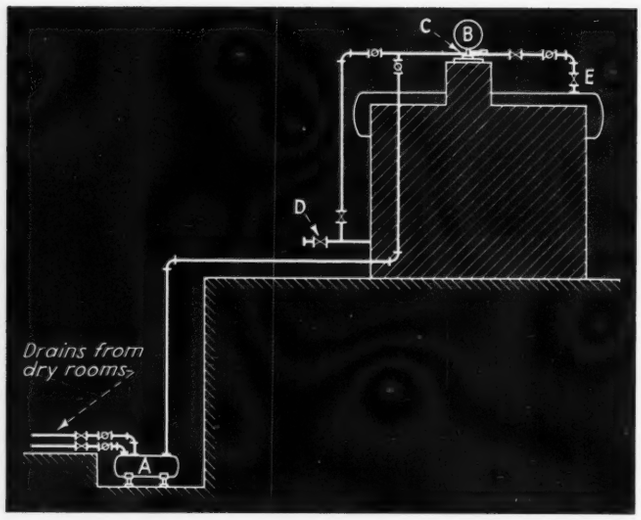
How to Locate the Trap

THE QUESTION DID NOT SAY how high the boiler is or how low the heating coils are. Although it is mentioned that the heating coil is quite a bit lower than the boiler, the depth is unknown. Neither is the steam pressure mentioned that is being carried on the coil.

I would find the vertical height from the lowest point of the heating coils in the dry room to the trap on the top of the boiler. If steam pressure in the heating coils is great enough, it will force water to the trap on top of the boiler. If the boiler is 16 feet high, and the lowest point of the dry room heating coils 3 ft below boiler-room level, then I would set the trap on top of boiler 3 ft above the normal level of the water in the boiler, making a total of 22 ft from lowest point of heating coil to trap.

To force water from lowest point in coil to the trap there must be a pressure of 11 lb per sq inch. (22 divided by 0.5 lb pressure equals 11 lb). Thus, there should





be at least 0.5 lb per sq in. for each foot vertical height, so this 11 lb will practically balance a column of water 22 ft high. Hence, the water of condensation will be forced to the trap if the trap-inlet is less than about 22 ft above the discharge of the coil.

Philadelphia, Pa. W T MULLEN

Water Leg on Boiler Will Do the Trick

AS I UNDERSTAND THIS QUESTION, there is a condensate return trap at the top of the boiler. The water leg in the sketch will do the trick, provided there is sufficient pressure to elevate the water to the trap. The water leg should be filled with water before the steam is turned on; otherwise, the steam will blow through and prevent condensate from sealing the water leg.

Also, it will be necessary to set the reducing valve at a pressure high enough to carry the water to the top of the boiler plus any additional needed to overcome friction in the fittings. I am assuming that this laundry carries 100 lb pressure on its boiler, and live steam is used in the dry-room coils.

Cleveland, Ohio. T E BROCK

Several Methods Use Single Trap

THERE ARE SEVERAL SYSTEMS involving the use of a single trap that can be applied to NTG's problem. One of the systems most commonly used employs a return trap or a non-return trap, depending upon the conditions of the specified installation.

A return trap delivers condensate directly to the boiler regardless of any difference in pressure between the apparatus drained and the boiler, and irrespective of any difference in elevation. The only requirement being that the condensate be supplied to the trap either by gravity or pressure.

Referring to the sketch, condensate is collected in the receiver at *A*, the receiver being placed at a location which will afford free flow by gravity. As the receiver is under pressure, the water is forced to the equalizer at *B*. This equalizer is mounted eccentrically and is normally in a horizontal position, held there by a counterweight. As the water is forced from the collector into the equalizer, the equalizer moves off balance.

When the balancing has been overcome, the steam valve *C* working through levers is opened and the water is forced out of the equalizer into the boiler through an independent connection or the blowoff pipe as shown at *D*. When the water in the equalizer has been removed to a point where the counterweight can again act, the equalizer is brought back to the horizontal position and the cycle is repeated.

The steam for operating trap *C* should be taken from the boiler drum as shown at *E*, so as to insure maximum pressure. Check valves should be installed where noted.

If the difference in elevation is too great, remembering that 1 lb pressure will raise the water approximately 2 ft, one trap will do the job; if the difference is great, then two traps in series can be used.

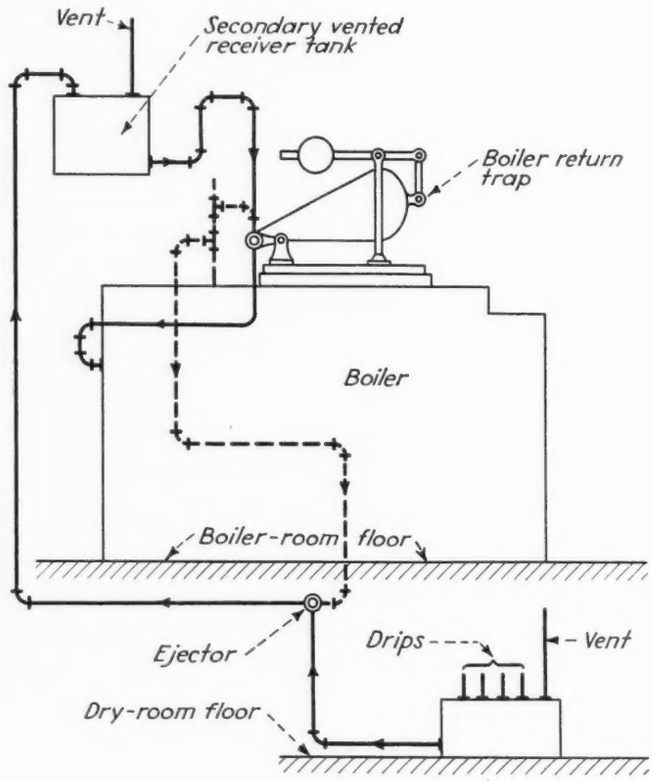
The system as noted is commercially manufactured, and will solve NTG's problem inexpensively.

Wilmington, Del. F M NEWELL

Use a Small Ejector

THIS PROBLEM is an examination question, and it is reasonable to suppose that any equipment not specifically barred can be used, especially if it is simple and low cost.

Obviously, it will be necessary to collect



the condensation in the dry room at some central point, and we will assume that the condensation flows by gravity to a vented tank or receiver, located at this point. To get the water into the boiler, we will have a tilting, or other suitable return, trap, installed a few feet above the water line. Our problem is to lift the water from the receiver in the dry room to the return trap above the boiler without using another trap or, presumably, other major equipment.

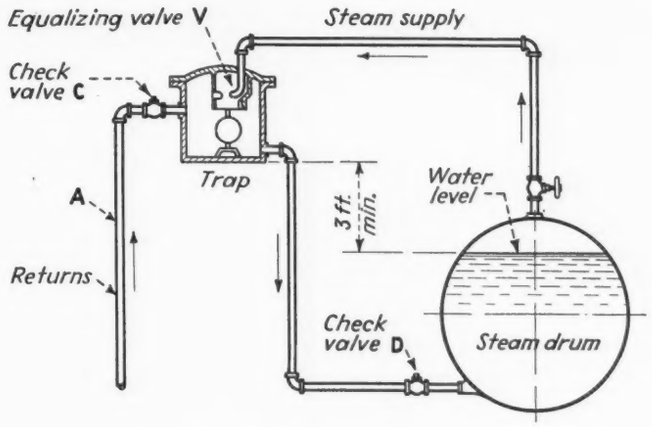
Of course, the drip water won't rise by itself, and the return trap won't suck, so we must provide some connection that will life the water from the receiver to the trap. We could make a hookup for this purpose with standard fittings, and some kind of an orifice nozzle, using a steam jet, to do the lifting, but it would be better, and just about as cheap, to buy a small ejector. It will be advisable, rather than trying to discharge the condensation directly into the trap, to provide a small vented receiver above the trap, from which the water can flow to the trap by gravity.

This is submitted as a somewhat tricky answer to a decidedly tricky question, and not as an example of good engineering practice. The right thing to do would be to invest in another trap, of the lifting type, to be used with the return trap, or to install a pump.

Bloomfield, N. J. J O G GIBBONS

"Equalizing" Valve

MY SKETCH shows an arrangement of a float trap for automatically returning condensate to a boiler. For this purpose the



trap must be placed 3 or more feet above the water line in the boiler, so that water may flow by gravity to the drum of the steam boiler when pressure is equalized by admitting boiler steam.

Condensate is forced into the trap from the dry-room coils, through pipe *A* until it reaches a level where the float opens equalizing valve *V* and permits steam from the boiler to enter the trap, thus equalizing the pressures. The water then flows into the boiler by gravity through check valve *D*.

At the end of discharge, the float closes the equalizing valve and another cycle begins. Check valve *C* prevents the water from being forced back to the return pipe. Practically any high-pressure trap may be converted into a return trap by proper installation of an "equalizing" valve.

Harmon-on-Hudson, N. Y. R S JULSRUD

15-lb Pressure Needed in Boiler

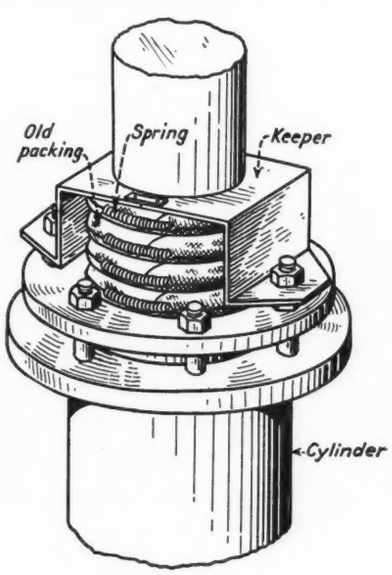
THE SOLUTION to NTG's problem hinges on two things—how much pressure is used in the heating coils, and how high does the condensate have to be lifted. It takes a little more than 0.5 lb of steam pressure per sq in. to balance a 1-ft vertical column of the same area.

Thus, in this problem, as the condensate discharge from the heater coils is 20 ft below the water inlet on the boiler, the pressure to be carried in the boiler would have to be approximately 15 lb per sq in. to care for the pressure drop and friction. Of course, if he has a high-pressure outfit, most any good boiler-return trap will solve his troubles if properly hooked up.

Chicago, Ill. G A HEINZE

Make Old Packing Protect the New

ON TAKING CHARGE OF A PLANT 16 years ago I found that the hydraulic baling press, operating at 5000 lb per sq in. pressure, gave trouble with the packing around the plunger. This packing leaked so badly that about 50 gal of make-up oil was required per month. I found that abrasive dust got onto the plunger, and was carried down into the packing by the movement of the plunger. Cutting of the packing and serious leakage soon occurred.



Curing the Trouble

To cure the trouble we repacked the stuffing box. Then, after cleaning the old packing, we installed it around the plunger above the stuffing box, as in the figure. We held each ring of packing in place by a wire with a short spiral spring between its ends. A thin-metal keeper, made in two parts and held by the packing gland bolts, shown in the figure, prevents the old packing from moving up with the plunger.

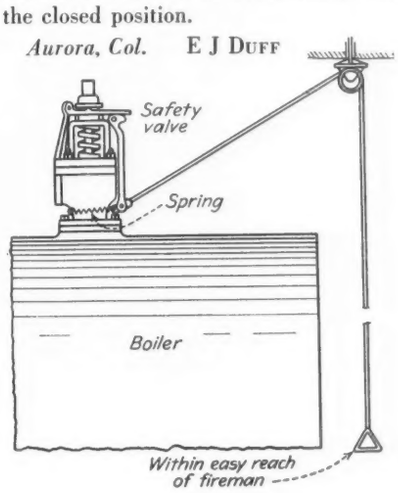
This old packing has done a 100% job of keeping abrasive dust out of the stuffing box, and the packing is still in good condition. Makeup oil amounts to about 20 gal per year instead of 600 before the repacking job was done.

Englewood, N. J. R BOETTINGER

Eliminates Climb to Safety Valves

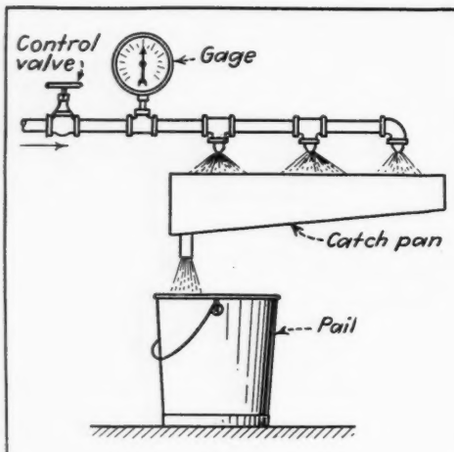
IN OUR PLANT WE HAD TO CLIMB UP ON TOP of the boilers to test the safety valves. We eliminated this inconvenience by connecting the lever on each valve by a rope so that it could be operated from the firing floor. A spring insures that the valve lever returns to the closed position.

Aurora, Col. E J DUFF



More About Flow Measurement

By PHIL SWAIN



Observation number	Gage reading, Lb per sq in.	Seconds to fill container	Times filled per hr	Flow, lb per hr
1	0	-	0	0
2	10	64	56	2240
3	20	46	78	3120
4	30	37	97	3880
5	40	32	112	4480
6	50	27	133	5320
7	60	24	150	6000
8	70	22	164	6560
9	80	21	171	6840

B

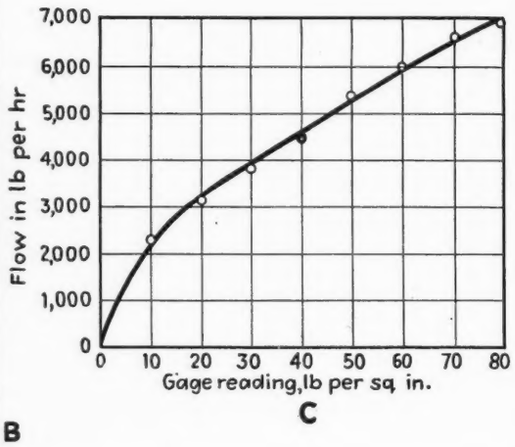


Fig. 1—Any combination of sprays backed by a pressure gage is a flowmeter. *A*—Measure time required to fill the pail for each of a series of gage readings. *B*—Tabulate flow for each measurement. *C*—Draw calibration curve

LAST MONTH this page showed how to figure the flow of water through orifices, also gave a time-saving orifice chart. But a man doesn't have to study any hydraulics to be sure that, for a given orifice, greater pressure will produce greater flow and the same pressure will always produce the same flow.

Thus, any sort of orifice or nozzle with a pressure gage anywhere behind it can be used to measure the flow through the nozzle. This elementary fact has many practical applications around the plant.

To make this clearer, consider the bank of spray heads, Fig. 1*A*. At any point between the control valve and the first spray head the engineer installs a pressure gage. For each gage reading there can only be one rate of water flow. If the flow can be measured once at various gage readings, and these points plotted, it will be easy to find the flow for any gage reading.

Assume that this is a rough-and-ready job to be done approximately, in a hurry. Take a convenient pail or other container and find (by weighing) how much water it will hold. Then adjust the control valve until the gage reads 10 lb. Wait until the water is flowing out of the catch pan at a steady rate, then shove the empty pail under the discharge and time the number of seconds required to fill the pail.

Repeat this process by 10-lb pressure steps, say. Then tabulate this information as shown in the first three columns of Fig. 1*B*. Now consider the 10-lb line in this table. At this gage reading, it took 64 seconds to fill the pail. Since there are 3600 seconds in an hour, the existing rate of flow would fill the pail $3600 \div 64 = 56$ times per hr. This gives column 4 of the table. If the pail holds 40 lb of water, the flow per hr at 10-lb gage reading will be $40 \times 56 = 2240$ lb. This process is repeated for each pressure.

With the table complete, plot the rates of flow against the corresponding gage readings and draw a smooth average curve through the points, Fig. 2*C*. Post this curve on a board near the gage and you have a flowmeter of fair accuracy. To get the flow rate at any later time, read the pressure gage and take the corresponding flow from the chart. This method can be applied to a variety of power and process devices, particularly cooling towers, washers and other spray equipment.

Getting back to standard water-flow-measuring devices, the V-notch weir, Fig. 2, is a convenient and accurate means of measuring water flowing in an open channel. Any good mechanic can machine an accurate V-notch from a brass plate as shown — also make a "hook" gage to measure the head of water above the bottom of the vee. For easy reading, the point of the hook is brought up to the surface *from below*, and head is read on scale above.

V-notches of either 60-deg notch or 90 deg are commonly used. Each head corresponds to a definite rate of flow, but the formula is somewhat complicated for everyday use. The data sheet on page 128 of this number gives the answer directly.

For accurate results, the following matters of construction and adjustment are important: (1) make the V-angle true 60 or 90 deg, (2) bevel notch to a sharp knife edge with flat side *upstream*, (3) be sure the box is considerably wider and deeper than the vee, (4) admit water well back of weir and behind baffles, (5) gage water level well back from weir, (6) in setting up the equipment, use a precision level to adjust scale so that the gage will read zero when hook is exactly level with bottom of notch.

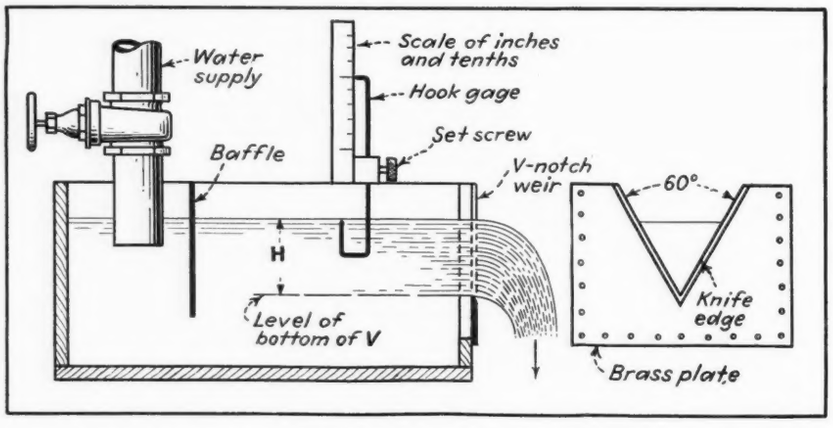


Fig. 2—V-notch weir (see Data Sheet No. 105, page 128, for computing chart)

ARGUMENT CORNER

Can You Explain It?

[*When we published the indicator card shown below (January, page 105) we expected to receive one or two replies. It didn't take the old marine engineers long to figure out what caused the freak card and plenty of dry-land engineers spotted the answer too. Because of the number and similarity of the answers, we give the highlights only.*—ED.]

S M ELONKA, *New York*, rang the bell first; he says "your diagram indicates that the engine was racing because the propeller was out of the water when the card was taken. The sudden drop of the pressure curve shows that the governor closed the throttle as the engine started to race. While I have never seen a card like this aboard ship, I will stake my reputation that this is what happened."

"I am a dry land engineer, so you can't expect much of answer," modestly states PAUL WARD, *Omaha*, but goes on to give the right answer just the same. E L HEMENWAY. JR, *Nashville, Tenn.*, hits it right on the head, "My guess is that the ship was on the crest of a wave or perhaps plunging down from the crest when the head-end of the cylinder was indicated. This accounts for the small volume enclosed between the admission and exhaust strokes. The crank end was indicated when the ship was either in the trough or climbing out, which would account for the card's shape."

From way inland at *Kansas City, Mo.*, the "old salt" S HECKROTTE puts his finger on the trouble, too, "I'd say the ship was in heavy weather. One stroke was taken with the propeller in the water and the other with the propeller racing. Maybe the throttle tripped from overspeed." A W NOE, *New York*, puts it this way, "Lady Osterley kicked up her heels and let the governor get in a lick just as the diagram was being traced. Note limited pressure rise due to steam shutoff by the butterfly."

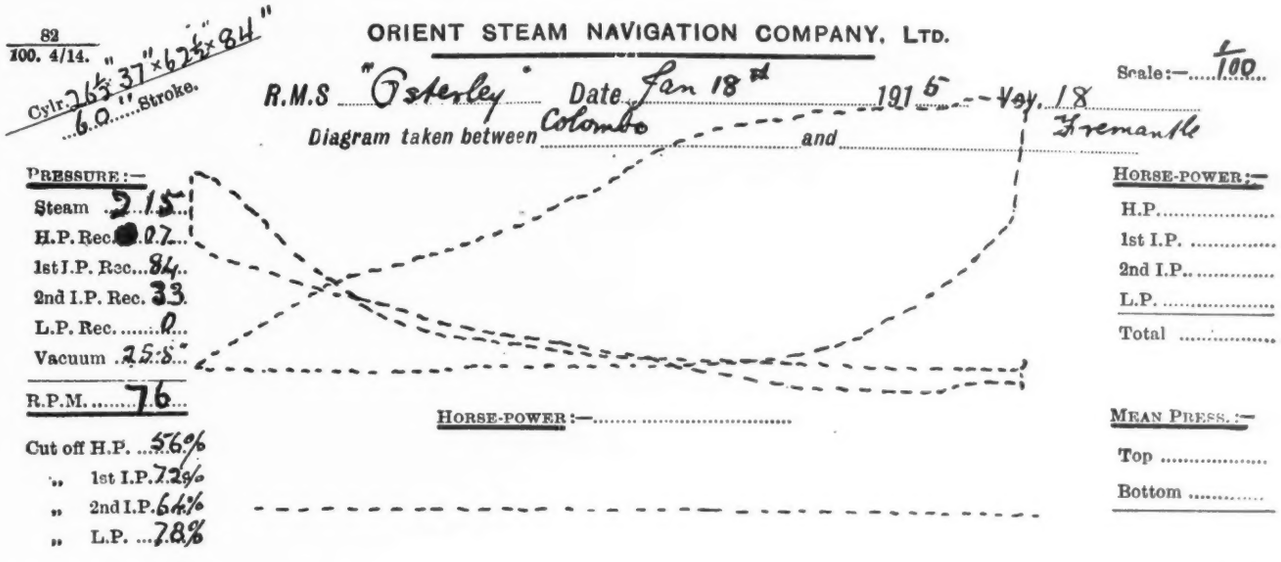
L S SIFF, *Dayton, Ohio*, figures it analytically, "Since there isn't anything seriously wrong with the engine or its valve setting, the explanation must lie in one or a combination of the fundamental motions of a ship about its axis." H T LIVINGSTON supplies some details, "The ship was in a heavy sea with a man standing throttle watch. The right-hand card was taken at full throttle, but as the left-hand one was about to be taken the throttle was closed to check the engine from racing. This accounts for the small amount of steam entering the h-p cylinder. The first i-p cylinder acted as a vacuum pump to reduce the pressure in the receiver, which accounts for the vertical drop at the right."

H A CAMPBELL, *Brockton, Mass.*, refers back to railroading days, "I know another situation where you can get the same result—a steam locomotive starting a heavy train. Things move very slow and you get a nice big card at one end, and then the drivers let go and spin, and *they can spin*. It is just a matter of timing. If one should set out to try to get such a card combination, one might get gray-haired and surely discouraged before this magic card turned up."

H F HALL, *Sarnia, Ontario*, also blames heavy weather and says, "Under these conditions, a marine governor, such as the Aspinall, would positively close the butterfly throttle valve and would not permit the valve to open until the speed of the engines had reduced. The exhaust line is normal, and from the point of exhaust closing the compression curve is clearly indicated, but on the valve opening for admission of steam the pressure caused by compression is shown to be higher than in the steam chest at that moment. Consequently there is a drop in pressure of approximately 50 lb per sq in. immediately the valve opens the port for admission of steam. Each of the remaining functions of the valve appear to be normal, but I would submit that the work performed as shown by the small diagram would be negative on each end and positive in the center of the card from the point where the exhaust and expansion lines cross."

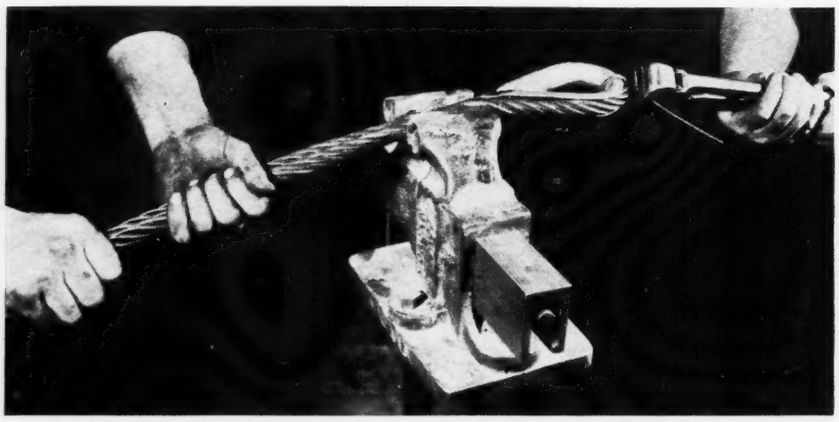
"I believe the boat was doing a Leaping Lena act at the time," is the way A E TOMLINSON, *Cleveland*, winds up his letter, and a good way to put it, too. N A HELMER, *South Amboy, N. J.*, says, "My guess is that the First was just about finished taking the card. Just as he started to take the last line, a big one rolled under the ship and she kicked her screw out of water and the oiler shut off the steam to prevent the engine from racing."

(*Continued on page* 138)



HOW TO APPLY WIRE-ROPE CLIPS

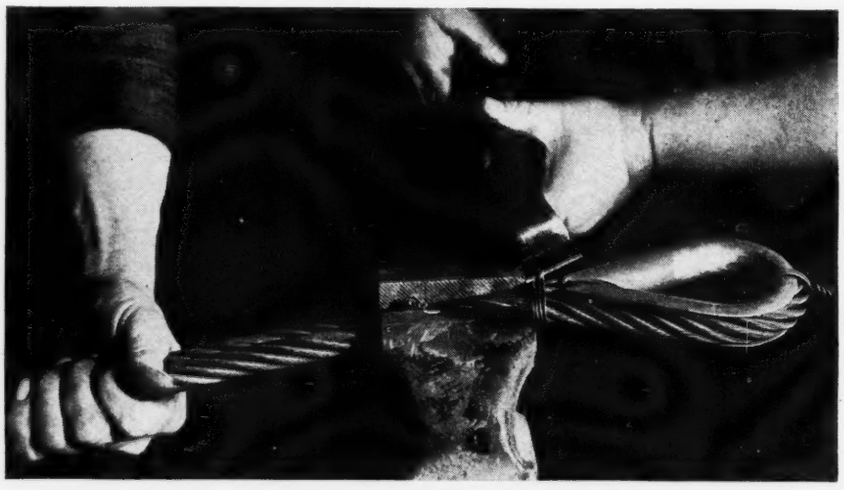
WIRE-ROPE CLIPS are used as a substitute for splices. Care must be taken, however, to apply the clips properly or they may injure the rope and create a hazard to life and property. The photos show these clips used to fasten a thimble into a rope. The rope length needed for attaching the thimble varies from 35 rope diameters for the smaller sizes to 50 for the larger ropes. The table gives the size of rope, number of drop-forged clips and spacing between them as recommended by American Engineering Standards. The clips are shown being applied in a shop, but they can be put on in the field by one man with a wrench.



1 **To attach a thimble into a rope, loop the proper length of rope around the the thimble, grip the loop firmly in a vise close to the thimble and securely bind the large end of the thimble to the rope**

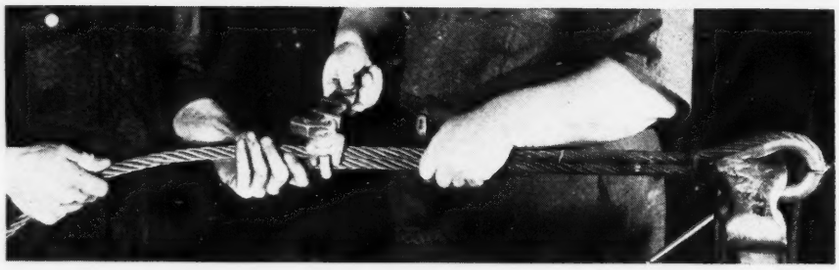
2 →

While still holding the loop in the vise securely bind the two sides of the loop together close to the thimble at the small end



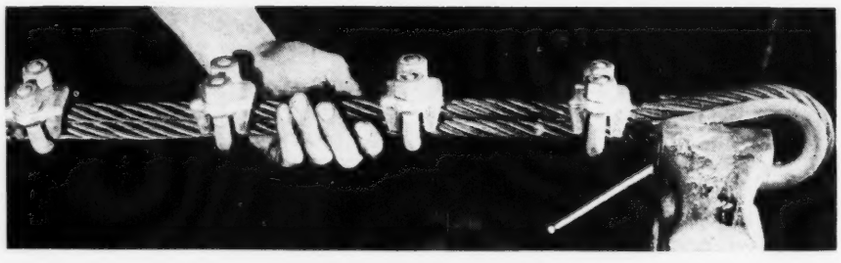
3

With the two sides of the loop resting squarely one upon the other, apply the clip farthest from the thimble about 4 in. from the short end of the rope and tighten it to a firm grip on the rope. Make sure that the saddle of the clip rests on the live end of the rope, as in the photo. This applies to all clips →



Clips Required to Make Fastenings Equal to 80% Rope Strength

Rope Dia. In.	Number of Clips	Space Between Clips, In.
5/8 and less	4	3 3/4
3/4	5	4 1/2
7/8	5	5 1/4
1	5	6
1 1/8	5	7
1 1/4	6	8
1 3/8	7	9
1 1/2	8	10
1 5/8	8	10
1 3/4	8	11
1 7/8	8	12
2	8	12



4 **Next, put on the clip nearest to the thimble and tighten it to grip the rope firmly. Apply the other clips and tighten them to a firm grip on the rope. Then, tighten all clips uniformly by giving each nut alternately one turn at a time. After the rope has been in use for a short time tighten all clips again. Stress tends to stretch the rope and reduce its diameter**

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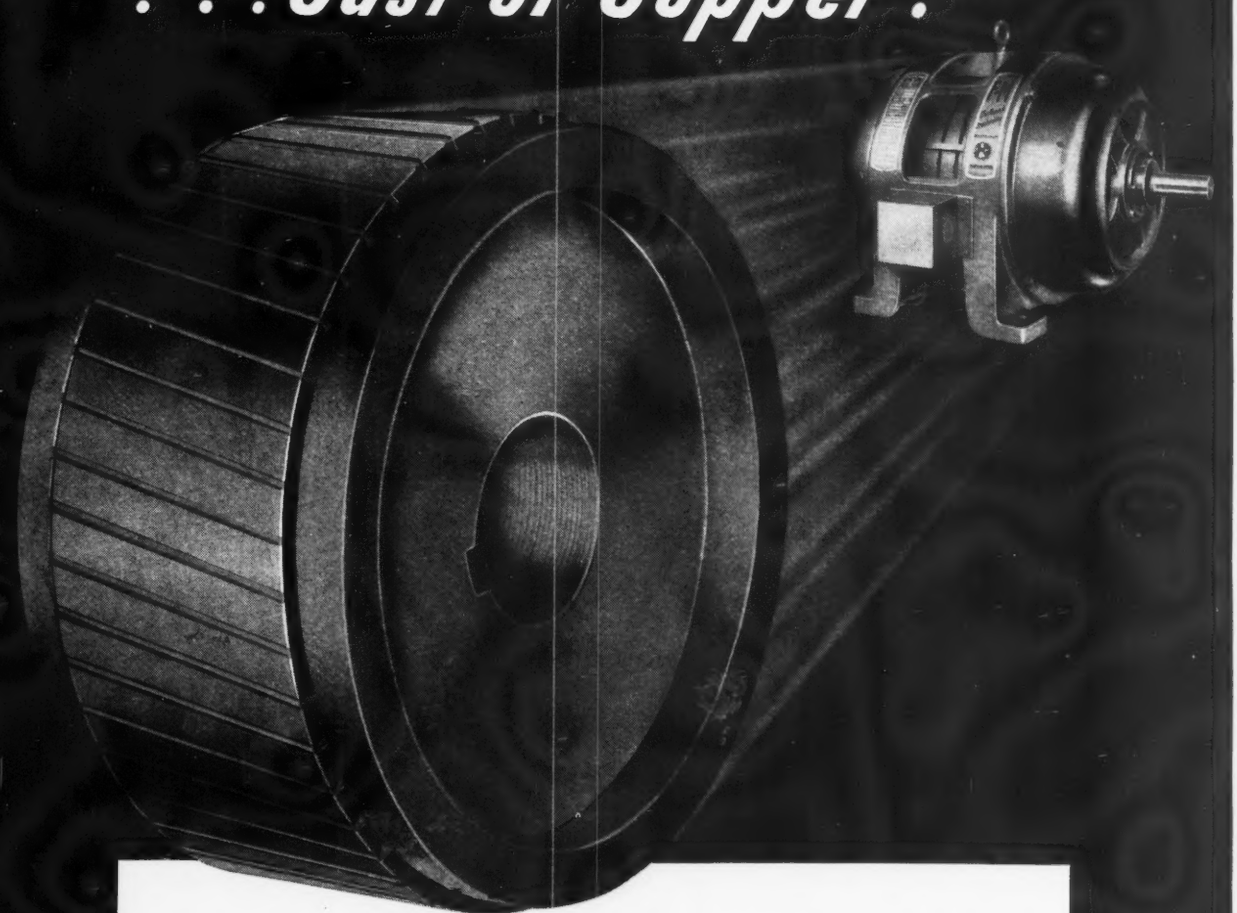

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Selecting Chimney Size for Natural Draft

Time was when chimneys were sized according to boiler horsepower. The logical procedure is to design one to produce the required draft when discharging the maximum weight of gases to be handled at probable stack temperature. J G Mingle gives the practical answer

A stack is nothing but a machine for pumping gas. The difference between air density and hot-gas density provides the motive power

▶ DESPITE THE FACT that proper and efficient operation of a steam boiler plant depends greatly on the draft-producing ability of the chimney, only too often does this important accessory get little attention either as to correctness of size or economy of construction. Almost since chimneys were first built, it has been the general custom to select a chimney size from a table based on boiler horsepower.

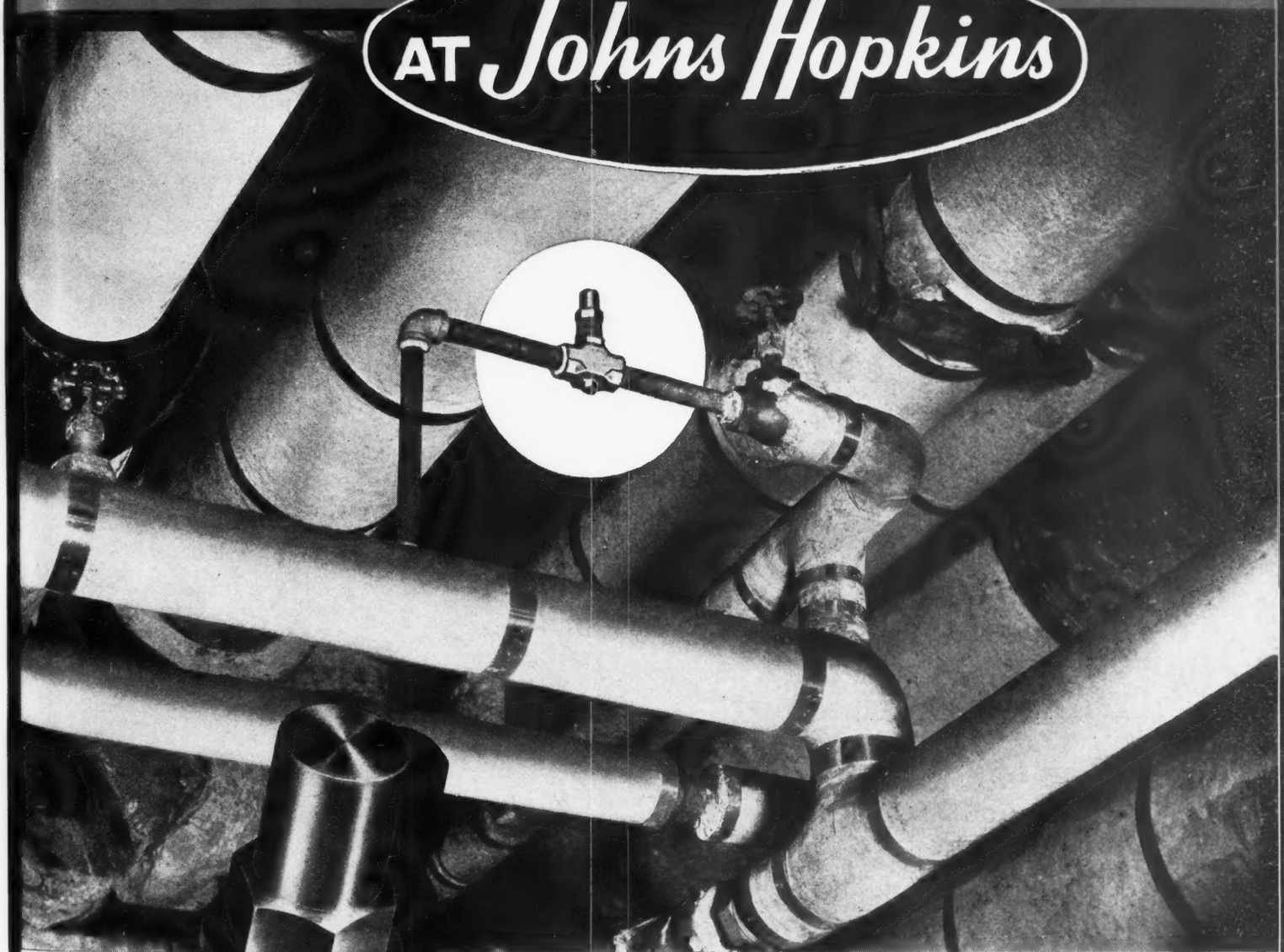
This practice is equivalent to selecting a size of chimney for gas flow to be handled with no accounting of the amount of draft required. Many chimneys in operation today are too short. too small in diameter or otherwise badly proportioned. Slipshod or haphazard selection of proportions can result in the erection of a "smokestack" rather than a chimney.

If chimney size is not adequate to meet the gas-flow and draft requirements of the fuel-burning equipment, insufficient air for proper and complete combustion will be drawn through the fire at high steaming

(*Continued on page* 116)

No Trouble or Repairs in Four Years' Continuous Service

AT *Johns Hopkins*



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Reports the Chief Engineer: "No trouble has ever been experienced and no new parts have been installed."

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YARWAY IMPULSE STEAM TRAP

Selecting Chimney Size for Natural Draft

(Continued from page 114)

MINGLE'S TABLES OF ECONOMICAL SIZES FOR NATURAL-DRAFT CHIMNEYS

DIAMETER		HEIGHT									
Weight of gases to be delivered, lb per sec	*Chimney diameter, ft*	*Required draft, in. water g*	*Chimney gas temperature, deg F* 350	400	450	500	550	600	638	800	1000
			Chimney height, ft								
5	2.8	0.45	114	102	93	86	81	77	74	65	59
10	3.7	0.50	127	113	104	96	90	85	82	73	66
15	4.4	0.55	140	124	110	105	99	94	90	80	72
20	4.9	0.60	153	136	124	115	108	102	98	87	79
25	5.4	0.65	165	147	135	124	117	111	106	94	85
30	5.8	0.70	178	158	145	134	125	119	114	102	92
35	6.2	0.75	191	170	156	143	134	128	122	109	98
40	6.5	0.80	208	181	166	153	143	136	130	116	105
50	7.1	0.85	216	192	176	162	152	145	139	123	111
60	7.7	0.90	229	204	187	172	161	153	147	131	118
70	8.1	0.95	242	215	197	181	170	162	155	138	125
80	8.6	1.00	254	226	207	191	179	170	163	145	131
90	9.0	1.05	267	238	218	200	188	178	171	152	138
100	9.4	1.10	280	249	228	210	197	187	180	160	144
110	9.8	1.15	292	260	238	220	206	196	188	167	151
120	10.1	1.20	305	272	249	229	215	204	196	174	157
130	10.5	1.25	318	282	259	239	224	212	204	181	164
140	10.8	1.30	330	294	270	248	233	221	212	189	170
150	11.0	1.35	343	305	280	258	242	230	220	196	177
160	11.3	1.40	356	317	290	268	251	238	228	203	184
170	11.7	1.45	368	328	300	277	260	246	237	210	190
180	11.9	1.50	381	339	311	286	269	255	245	218	197
190	12.2	1.55	394	350	321	296	278	264	253	225	204
200	12.4	1.60	406	362	332	306	286	272	261	232	210
225	13.0	1.65	420	373	342	315	296	280	269	239	216
250	13.6	1.70	432	384	352	325	304	289	278	246	223
275	14.1	1.75	445	396	363	334	313	298	286	254	230
300	14.6	1.80	458	407	373	344	322	306	294	261	236
325	15.1	1.85	470	418	384	354	331	314	302	268	243
350	15.5	1.90	483	430	394	362	340	323	310	276	250
375	16.0	1.95	496	441	404	372	349	332	318	283	256
400	16.4	2.00	508	452	414	382	358	340	326	290	262

Based on sea-level elevation, mean coefficient of friction of 0.018 for sooted surfaces, and a mean atmospheric temperature of 62 F.
Variation in chimney-gas temperature has but slight effect on diameter.
For practical purposes, select required diameter to nearest 0.50 ft and required height to nearest 5 ft.

rates. In this way the chimney itself can contribute to making smoke.

Operating characteristics of a natural-draft chimney are similar in all respects to those of a centrifugal fan or pump. It is no more possible to select a proper size chimney from a table based only on boiler horsepower than it is possible to choose the right fan or pump from the amount of gas or water flow alone. Just as it is necessary to know the total static pressure or the total dynamic head against which a fan or pump must operate, it is essential to know the total dynamic draft which the chimney must supply.

In determining the size of a new chimney for definite operating conditions, first ascertain maximum draft and capacity requirements. The latter can be calculated readily from the fuel-burning capacity of the firing equipment (POWER, December, 1940, pages 87-95). Maximum draft requirement, total dynamic draft, is the sum of the total resistances through the grates and fuel bed, boiler and setting, economizers or other auxiliaries, breeching, contraction or enlargement of ducts, and velocity-head loss, all calculated for the maximum gas flow and expressed usually in inches water gage.

The performance of a natural-draft chimney depends on (1) atmospheric temperature and density, (2) chimney-gas temperature and density, (3) atmospheric pressure as affected by altitude, (4) friction coefficient, (5) quantity of gas flow, (6) total dynamic draft, (7) velocity of chimney gas. Of these, all of which affect chimney size in one way or another, chimney-gas velocity is the only one that must be assumed at some arbitrary value before computing an economical chimney size.

Since both height and diameter vary with chimney-gas velocity, there will be as many different combinations of height and diameter, for a given gas flow, as there are assumed values of velocity. To limit the range of choice, an economic criterion, cost of construction can be calculated for various combinations of height and diameter.

The cost of a chimney depends on both height and diameter. Generally, a chimney that will handle the maximum gas flow at required draft with minimum total product of height times diameter will represent least cost of construction.

The equation for design velocity corresponding to most economical construction is determined by developing a relationship for HD (height times diameter) in terms of various operating factors. After a process of differentiation and substitution, the following equations for economical diameter and corresponding height are obtained:

$$D_e = \frac{0.27\left(\frac{W\ T_c}{B_o\ w_c}\right)^{2/5}}{\left[\frac{0.725\ T_c\ \left(\frac{w_o}{T_o}-\frac{w_c}{T_c}\right)}{f\ w_c}\right]^{1/5}}$$

$$H_e = \frac{D_r}{2.79\ B_o\left(\frac{w_o}{T_o}-\frac{w_c}{T_c}\right)}$$

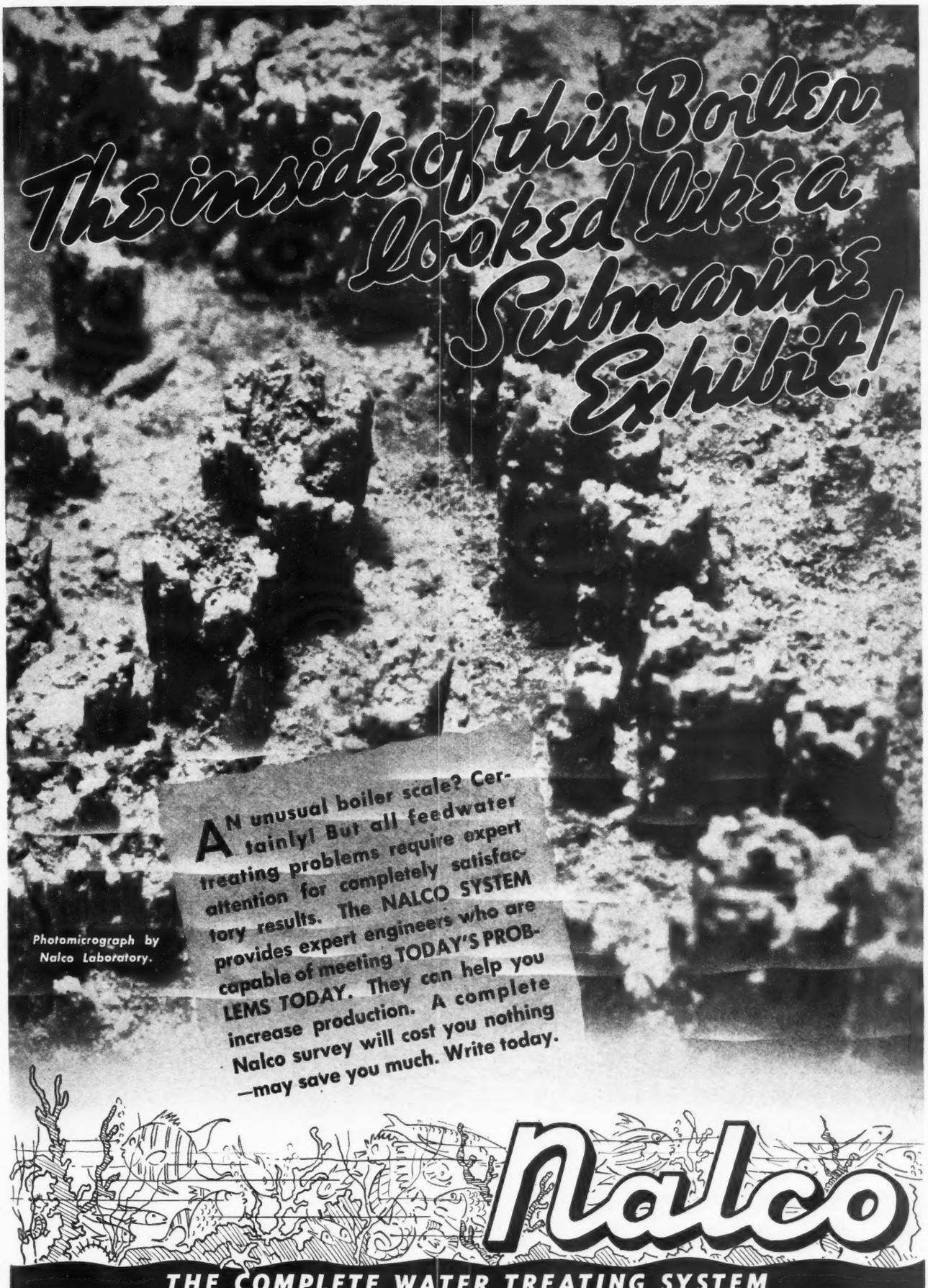
in which:

D_e = economical chimney diameter, ft
H_e = economical chimney height, ft
W = chimney gas flow, lb per sec
D_r = total dynamic draft, in. wg
T_o = temperature of atmosphere, F abs
T_c = temperature of chimney gas, F abs
w_o = density of air at 62 F at sea level, lb per cu ft
w_c = density of chimney gas at 62 F at sea level, lb per cu ft
B_o = atmospheric pressure corresponding to altitude, in Hg
f = friction coefficient.

The amount of gas to be handled and the draft required depend on the size and type of boiler installation and, of course, both factors vary over a wide range. For a given chimney, maximum values for both flow and draft should be used in the equations.

To arrive at a first approximation to a definite size, assumed values may be assigned to other factors. Mean

(Continued on page 118)


The inside of this Boiler Looked like a Submarine Exhibit!
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Selecting Chimney Size for Natural Draft

(Continued from page 116)

atmospheric temperature for the temperate zone is 62 F, for example, giving an absolute temperature for T_a of 62+460=522. Density of air at sea level and 62 F. w_a, is 0.0761 lb per cu ft. Flue-gas density, corrected to the same temperature and pressure is, w_c, 0.08. For sea level the barometric pressure is, B_a, 30 inches Hg. The friction factor, f, can be taken at 0.018 for sooted surfaces. Substituting these values, the equations simplify to:

$$D_c = \frac{0.32\,(W\,T_c)^{2/5}}{(T_c - 548)^{1/5}}$$

$$H_c = \frac{D_r}{0.0122 - \frac{6.7}{T_c}}$$

Then for a chimney gas temperature of 600 F, for example, T_c=1060 and:

$$D_c = 1.5\,(W)^{2/5}$$
$$H_c = 170\,D_r$$

The table gives the economical size for natural-draft chimneys based on these assumed conditions. Diameters are based only on amount of gas to be handled and are independent of chimney gas temperature between 500 and 700 F. Required heights are based on total dynamic draft and vary as the gas temperatures shown.

The table is based on sea-level conditions. For other altitudes it will be noted that diameter varies inversely as the two-fifths power of the atmospheric pressure, and the height inversely as the first power of the same variable. Thus, the diameter will increase approximately 1% and the height about 4% for each 1000 ft elevation. Ordinary variations in density of chimney gas have little effect on either diameter or height.

Friction Factor

The friction factor for sooted surfaces, on which the table is calculated, results from experience. It applies to the inside surface of all types of chimney after soot has formed. New brick, brick-lined steel and reinforced-concrete chimneys will have slightly less friction loss and new steel stacks considerably less. All chimneys coat with soot in time, and the 0.018 friction factor gives very good results.

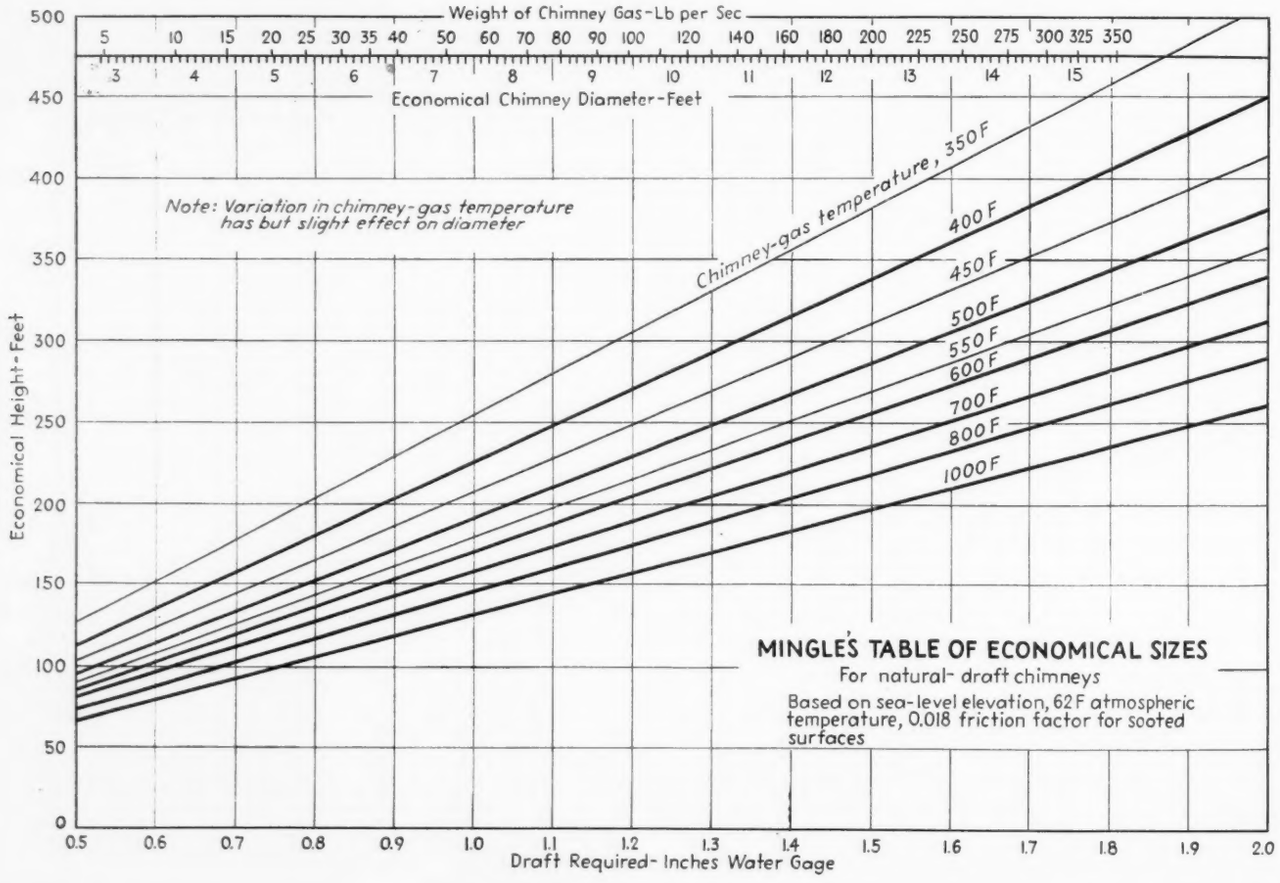
The performance of a chimney suffers when atmospheric temperature rises and improves when the temperature is low. While correction may be made to the table figures by working out the formulas completely, it is usually sufficient to take account of probable high-temperature conditions by adding 4% to the height of the stack for each 10 F above 62 F. The diameter is little affected by atmospheric temperature and no correction is needed.

The sizes given by the table represent *economical* chimney proportions. For any one set of assumed operating conditions there are a multitude of chimney dimensions that will satisfy the requirements. The table indicates the approximate proportions that will give least cost under normal conditions.

Correction on Factory 4

IN THE ARTICLE, "Results at Factory 4", page 103, December, 1940, POWER, the top line for August 12, states machine line 180 lb, engine 380 lb, total 760 lb. I believe the author meant this to be 560 lb.

[*Apologies to all—it was necessary to ink Mr Campbell's original chart so it would reproduce clearly. It was in this step that the "5" got to be a "7"*—ED.]


Weight of Chimney Gas-Lb per Sec
5 10 15 20 25 30 35 40 50 60 70 80 90 100 120 140 160 180 200 225 250 275 300 325 350
3 4 5 6 7 8 9 10 11 12 13 14 15
Economical Chimney Diameter-Feet
Note: Variation in chimney-gas temperature has but slight effect on diameter
Chimney-gas temperature, 350 F
400 F
450 F
500 F
550 F
600 F
700 F
800 F
1000 F
Economical Height-Feet
500 450 400 350 300 250 200 150 100 50 0
MINGLE'S TABLE OF ECONOMICAL SIZES
For natural-draft chimneys
Based on sea-level elevation, 62 F atmospheric temperature, 0.018 friction factor for sooted surfaces
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Suction-Discharge Design Aids Fan Performance

Getting air or flue gas into and out of a fan with minimum pressure loss requires cooperation between plant designer and fan manufacturer. Theodore Baumeister, Jr, Columbia University professor and fan consultant, points to the need for talking things over

▶ SUITING BOILER FANS to necessary limitations in suction and discharge duct arrangement demands active and effectual exchange of information between fan manufacturer and plant designer if full steaming capacity of the boiler plant is to be developed without excessive fan installation and operating costs. Fan users often fail to realize the importance of inlet and outlet conditions on fan capacity.

Fans usually meet their performance specifications on test where codes require straight duct runs and somewhat idealized conditions. In practice, however, the presence of dampers, air heaters and elbows may so distort gas flow to or from the fan enough to reduce seriously actual capacity. If such conditions are recognized at the outset of the design, attempts can first be made to reduce their effects to a minimum and, second, the fan design can be adapted to the actual conditions. Similar effects in the application of pumps have long been recognized, as, for example, the adaptation of impeller designs to the suction conditions encountered with condensate and boiler-feed pumps.

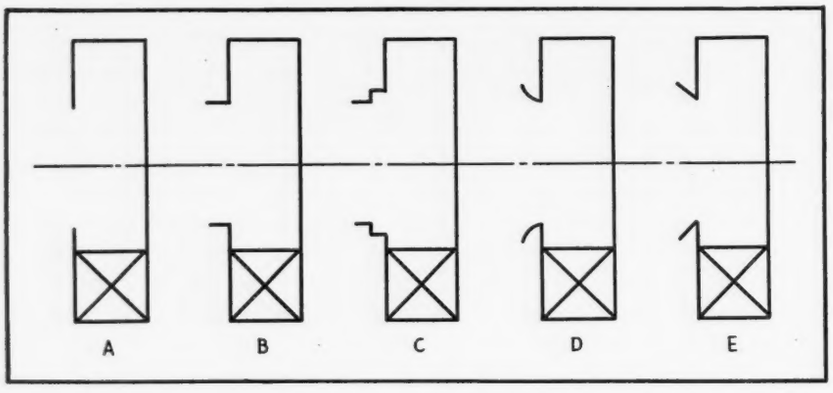

Fig. 1—Bell-mouth free-fan inlets offer less resistance than sharp-edged orifices. These five inlets are in order of preference from left to right

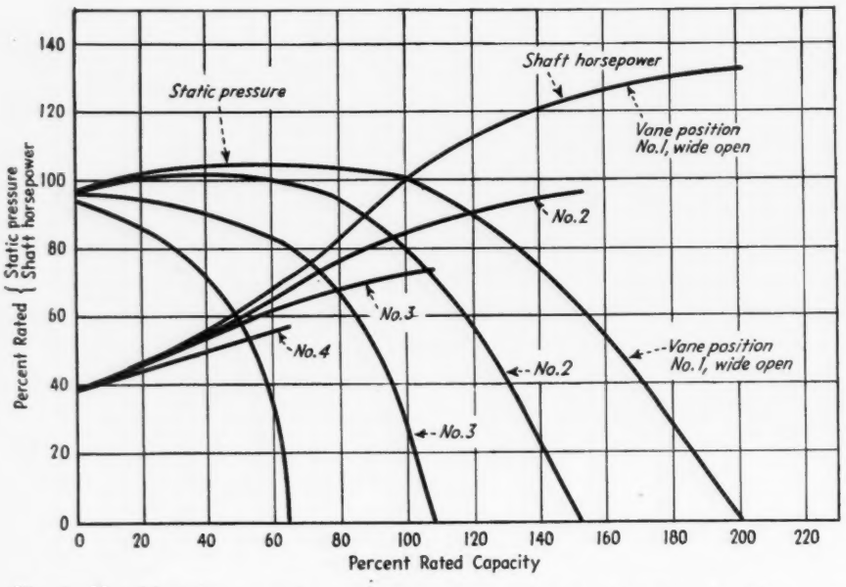

Fig. 2—Movable inlet vanes for control of volume flow produce a noticeable power saving over simple damper control for constant-speed drive

Bell-Mouth Inlets

Even in the simplest case of free-inlet forced draft fans, Fig. 1, many do not instinctively recognize the marked difference between more-or-less sharp-edged inlet construction and the much superior variations of bell-mouth shapes. Also, the head loss varies inversely as the fourth power of the diameter of opening, leading to maximum practical inlet dimensions. To this, the user must contribute care in not allowing bearings, pulleys, belts, gears, motors, engines, or turbines to be placed in such a position to obstruct the fan inlet to throttle the supply and to disturb the stream-line flow.

The importance of inlet flow conditions can be seen from the effect of vanes used for control of air volume at part loads. Changes in direction of approach are utilized to vary the fan performance widely, Fig. 2, thus effecting a considerable power saving where constant-speed motors drive the fans. Fixed vanes, a less expensive construction, give a quite different characteristic performance, Fig. 3, but these too are seen to have a relatively great influence on the way a fan operates.

Induced-draft fans present a larger variety of difficult problems. Usu-

(*Continued on page* 122)

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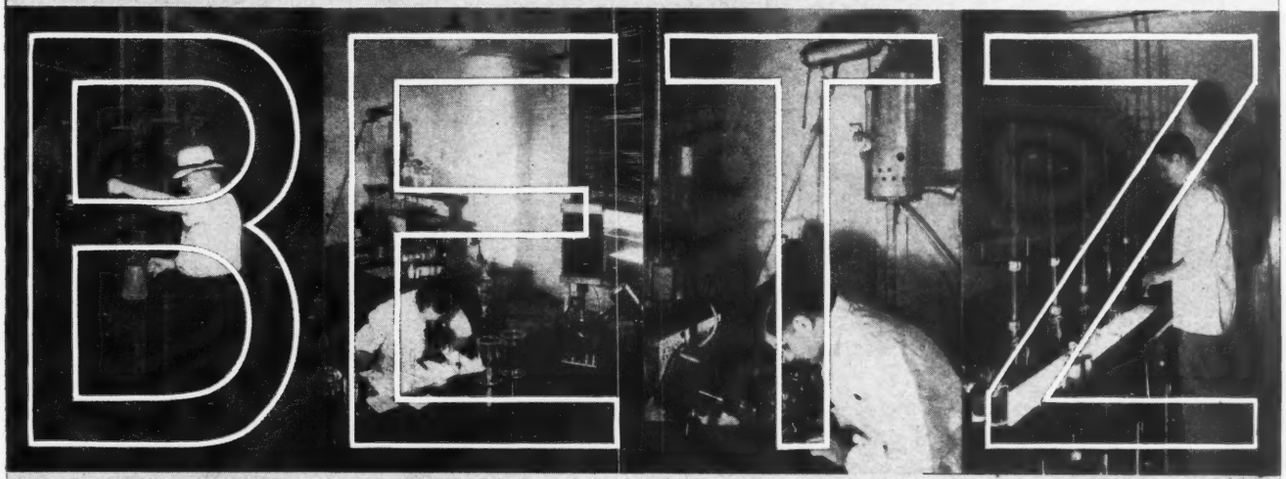

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Suction-Discharge Design

(Continued from page 120)

ally there is a connecting duct leading to the fan inlet that produces a flow pattern widely different from the conditions of free inlet. Marks and Winzenburger (see bibliography) reported an investigation of the influence of various inlet-box designs on the performance of a radial-tip fan. A study of their results shows great differences in the static pressure, horsepower and static efficiency of a single fan with scroll and rectangular inlet boxes, with and without guide vanes or vertical guide sheets.

Test Results

While these tests were skillfully conducted under code conditions, long runs of straight duct and supplementary straighteners were employed and it is not a simple matter to interpret the data in terms of an actual layout. No alteration of fan-wheel or fan-discharge housing dimensions, proportions or angles was made for each type of inlet-box construction. The test results thus show the influence of the inlet-box on one specific wheel and case when arranged for operation in accordance with test-code specifications.

A survey of these data might lead to the conclusion that induced-draft fans are best designed with a "modified rectangular inlet box with guide sheets". This choice, based on no further study, might not be the best possible solution. Typical test-code arrangement, Fig. 4, with a long straight run of duct, is seldom met in practice where close connection to equipment, short ducts, elbows and turns, abrupt transformation pieces, dampers, blast gates and louvres are the rule rather than the exception.

Evidence of wide divergence between code requirements and actual practice can be found in the layout of any boiler-room induced-draft-fan installation. Arrangements are necessarily crowded. This places a burden of proper fan selection on the purchaser, and the facilities and experience of the fan manufacturer should be sought for guidance.

The connected duct system may have a far greater effect on over-all performance than seems to be recognized by fan users. If the presence or absence of a few guide vanes in the inlet scroll can alter the available fan capacity by a ratio of two-to-one, as indicated by the Marks-Winzenburger tests, consider what must be the effect of simple dampers set close to the fan suction, as in Fig. 5.

Damper Arrangements

Half a dozen different damper arrangements are shown for location at position *A-A*. Each of these arrangements will distort the flow to the inlet box and produce a different flow pattern. Each will have its own peculiar effect on the static-pressure and horsepower characteristics of the fan. Fan acceptance tests are not ordinarily conducted with such dampers in place. The fan user, therefore, must exercise both judgment and skill to insure selection of a fan of adequate capacity.

The damper arrangement is but one of many details that occur in practice to affect fan performance adversely. Marks with his co-workers and Carrier have investigated and reported on the influence of elbows and duct arrangements in conjunction with various inlet boxes. The results cannot be conveniently summarized and reference to the original sources by those considering fan installations is recommended. The test data all demonstrate the considerable effect of inlet duct construction. The data are given for laboratory-controlled conditions and it must be recognized that the effects may be even more severe in field practice.

Fan discharge conditions can also

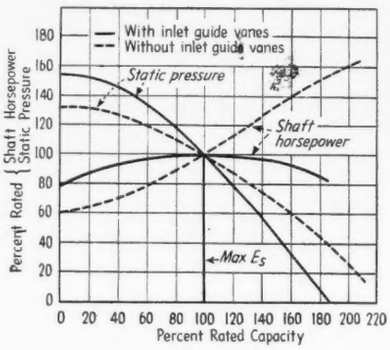


Fig. 3—Fixed-inlet vanes result in a less expensive fan and give typical self-limiting horsepower characteristics

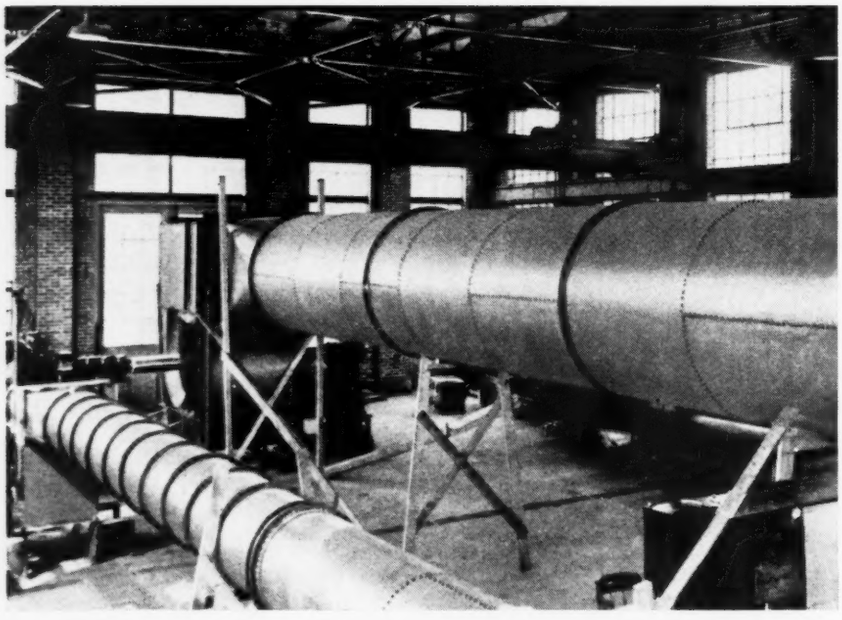
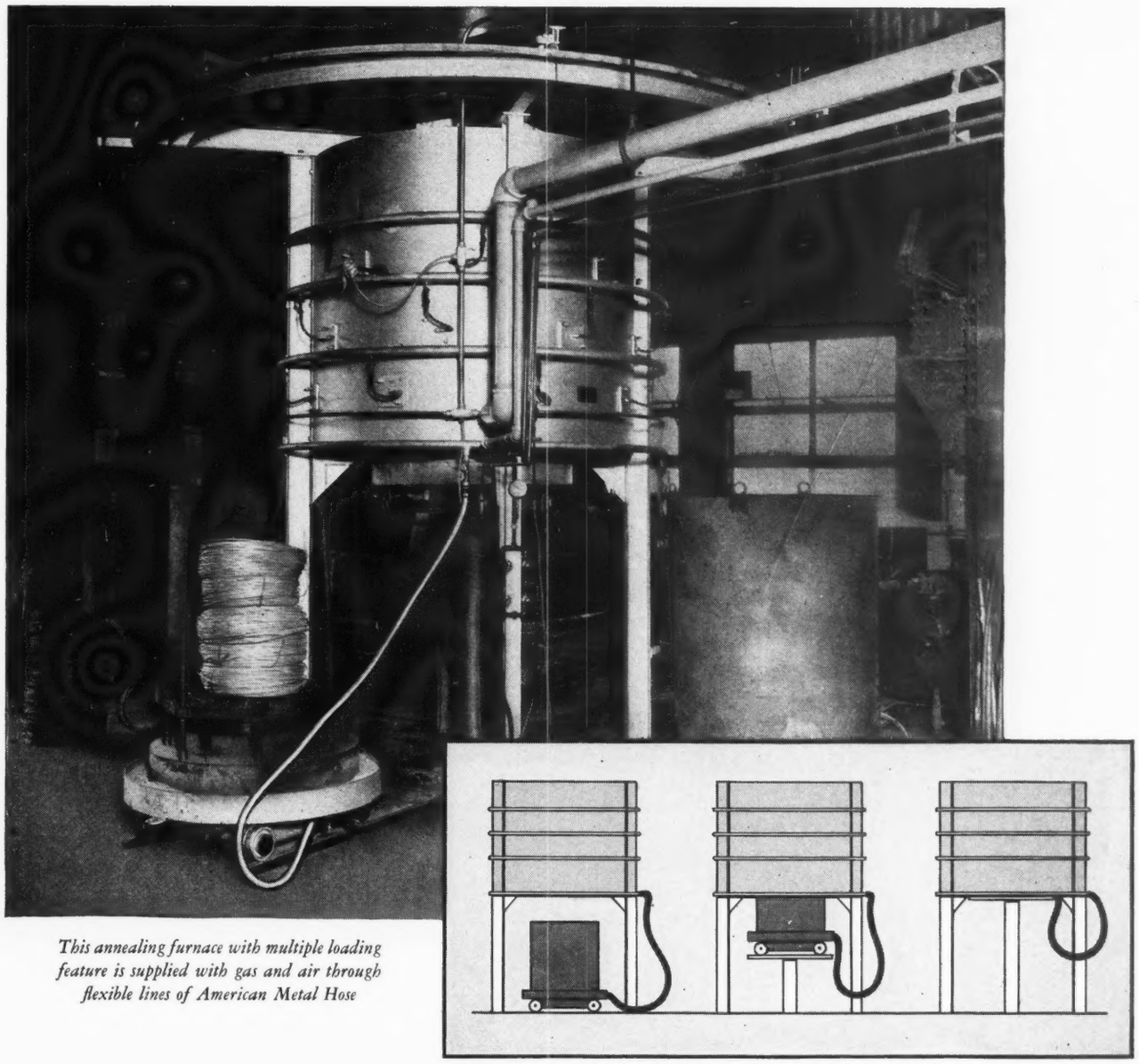


Fig. 4—Code arrangement of shop test requires use of long straight run of duct rarely found in actual installations

hamper performance if the disturbing effect is close to the fan as, for example, certain types of transformation pieces. Blocking part of the fan outlet by a damper arrangement or an abrupt change of section close to the fan will result in performance less than test measurement employing straight full-size duct. The presence of an evasé section or expanding transformation piece immediately after the fan will not necessarily assure uniform velocity distribution over the larger area, particularly if followed by a change of direction which causes "crowding" in the outer part of the transformation piece or fan scroll.

Further evidence and example might illustrate the important significance of suction and discharge conditions, but should not be necessary to drive home

(*Continued on page* 124)



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Suction-Discharge Design

(Continued from page 122)

the principle that fan user and manufacturer would both profit by getting together over the duct layout before the fan is ordered, built and tested. Both have a stake in the over-all performance of the fan as a part of the boiler installation.

Oversize Fans

When such cooperation is lacking, either the user needs to specify an oversize fan to be sure of overcoming adverse duct conditions or the manufacturer must take the initiative and sell an oversize fan where he suspects trouble may result. In either case, the extra margin of capacity must be paid for by one or the other, a cost which could have been eliminated by mutual exchange of information.

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Carrier and Madison, Fan Engineering, Buffalo Forge Co.

Derry, Eliminating Inlet Loss in Induced-Draft Fans, *Power Plant Engineering*, Oct. 1, 1928.

Marks, Lomax and Ashton, Influence of Bends in Inlet Ducts on the Performance of Induced-Draft Fans. *Transactions ASME*, FSP-1933.

Marks and Winzenburger, Influence of Inlet Boxes on the Performance of Induced-Draft Fans. *Transactions ASME*, FSP-1932.

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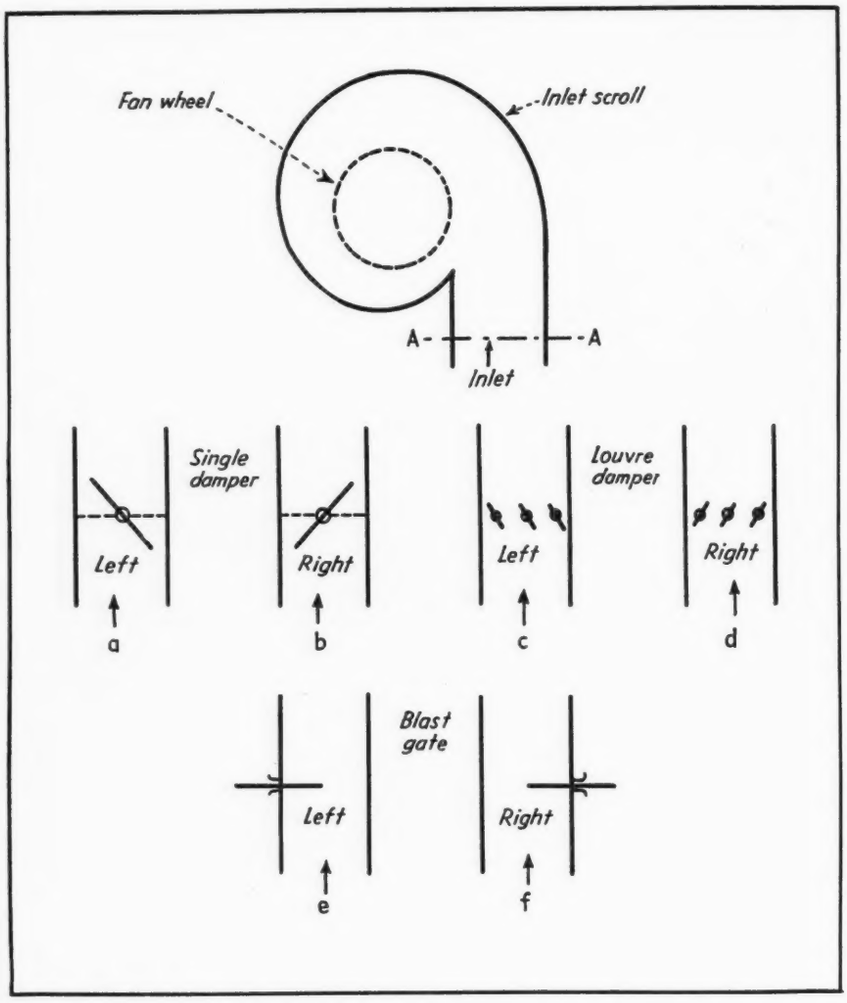

Fig. 5—Six alternate arrangements of induced-draft-fan inlet dampers that seriously affect fan performance. Judgment and skill enter choice for a given installation

CURRENT COMMENT

Back in the Days of the Old Chief

"Reminiscences about the Old Chief" have proved to be very interesting. There has been an occasional mention of "so and so" who was an ex-marine engineer. There are quite a few operating men in plants today who served their first years aboard ships. Their lot, in the early days, was not exactly to be envied. Take the following instance as a humorous, and rather exasperating, example of their trials and tribulations.

We hit a southern port of the U. S. on a Sunday morning with the mercury standing at 110 F. After we tied up, the chief came down below and announced that there would be no shore leave. He wanted the high-pressure and low-pressure heads pulled and high-pressure valve rings renewed. The engine, by the way, was a big triple, 2400 hp to be exact.

Well, we pulled the two heads, the chief had his look at the liners and we renewed the valve rings. Tuesday morning found us throwing the head on the valve chest back in place. We began picking up the various tools used on the job. The third reported that one eyebolt was missing. We looked in the bilges, tore up every bit of floor plate, searched the log desk, behind the generator, in fact, combed the engine room from skylights to tank tops with a fine-tooth comb. The chief came down and announced that the heads would have to be torn off again and the cylinders inspected before he would jack the engine over.

By this time, those famous Texas mosquitoes had invaded the engine room, and along with the heat had made life rather miserable. We tore the heads off, looked into the valve chest, cursed and sweated. It was Wednesday before we had her thrown back together. We were all standing in front of the log desk, trying to think of some solution to the missing eyebolt. One of the oilers grabbed Pedro, the Spanish wiper, as he passed. He held up an eyebolt and made signs to Pedro, asking if he had seen the bolt. Pedro's English was rather limited—I believe he knew just one sentence, and that was to request a glass of beer. Pedro reached into his

(*Continued on page* 168)

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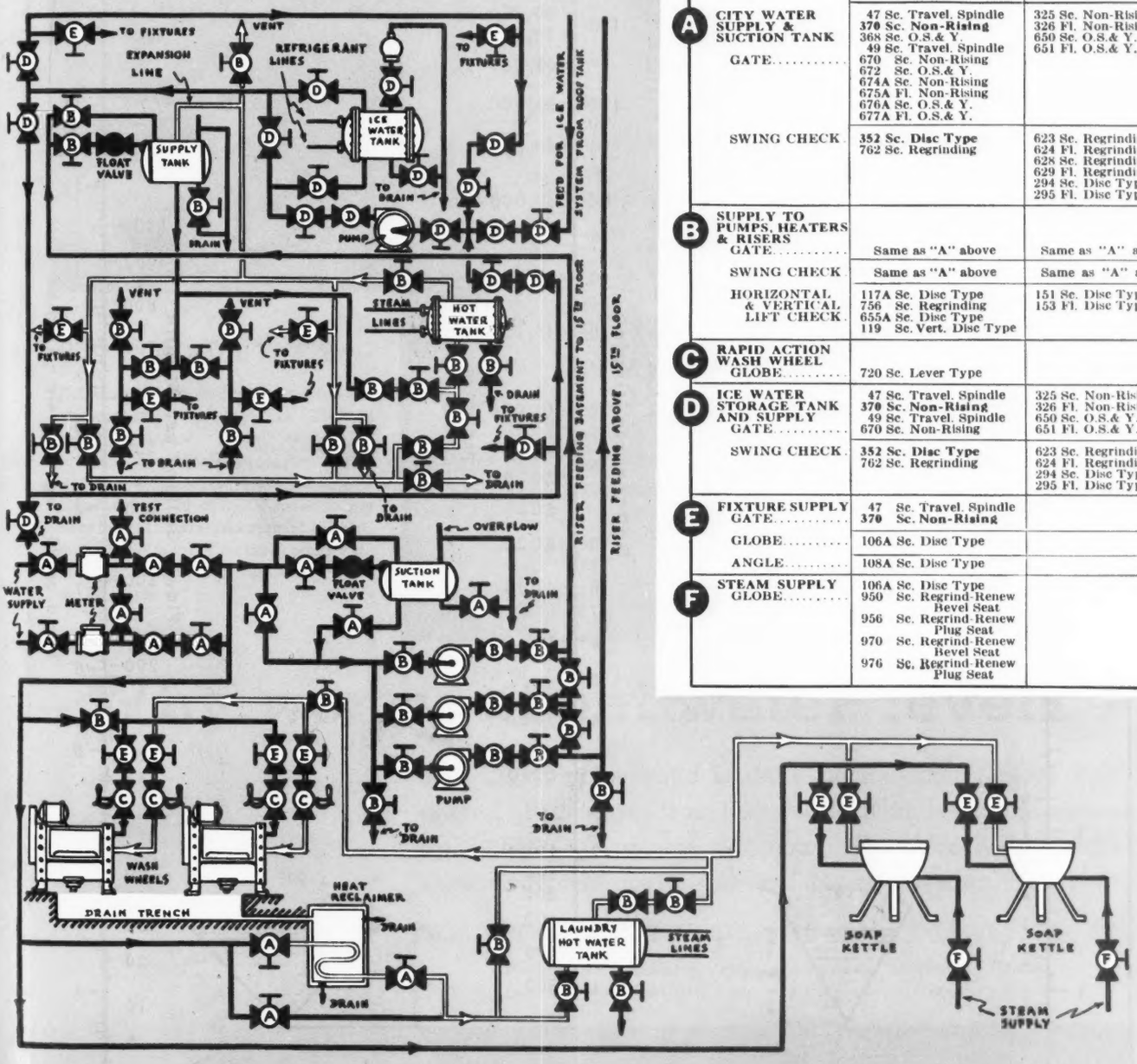

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	GATE	670 Sc. Non-Rising 672 Sc. O.S.& Y. 674A Sc. Non-Rising 675A Fl. Non-Rising 676A Sc. O.S.& Y. 677A Fl. O.S.& Y.	
	SWING CHECK	**352 Sc. Disc Type** 762 Sc. Regrinding	623 Sc. Regrinding 624 Fl. Regrinding 628 Sc. Regrinding U.P. 629 Fl. Regrinding U.P. 294 Sc. Disc Type 295 Fl. Disc Type
B	SUPPLY TO PUMPS, HEATERS & RISERS GATE	Same as "A" above	Same as "A" above
	SWING CHECK	Same as "A" above	Same as "A" above
	HORIZONTAL & VERTICAL LIFT CHECK	117A Sc. Disc Type 756 Sc. Regrinding 655A Sc. Disc Type 119 Sc. Vert. Disc Type	151 Sc. Disc Type 153 Fl. Disc Type
C	RAPID ACTION WASH WHEEL GLOBE	720 Sc. Lever Type	
D	ICE WATER STORAGE TANK AND SUPPLY GATE	47 Sc. Travel. Spindle **370 Sc. Non-Rising** 49 Sc. Travel. Spindle 670 Sc. Non-Rising	325 Sc. Non-Rising 326 Fl. Non-Rising 650 Sc. O.S.& Y. 651 Fl. O.S.& Y.
	SWING CHECK	**352 Sc. Disc Type** 762 Sc. Regrinding	623 Sc. Regrinding 624 Fl. Regrinding 294 Sc. Disc Type 295 Fl. Disc Type
E	FIXTURE SUPPLY GATE	47 Sc. Travel. Spindle **370 Sc. Non-Rising**	
	GLOBE	106A Sc. Disc Type	
	ANGLE	108A Sc. Disc Type	
F	STEAM SUPPLY GLOBE	106A Sc. Disc Type 950 Sc. Regrind-Renew Bevel Seat 956 Sc. Regrind-Renew Plug Seat 970 Sc. Regrind-Renew Bevel Seat 976 Sc. Regrind-Renew Plug Seat	

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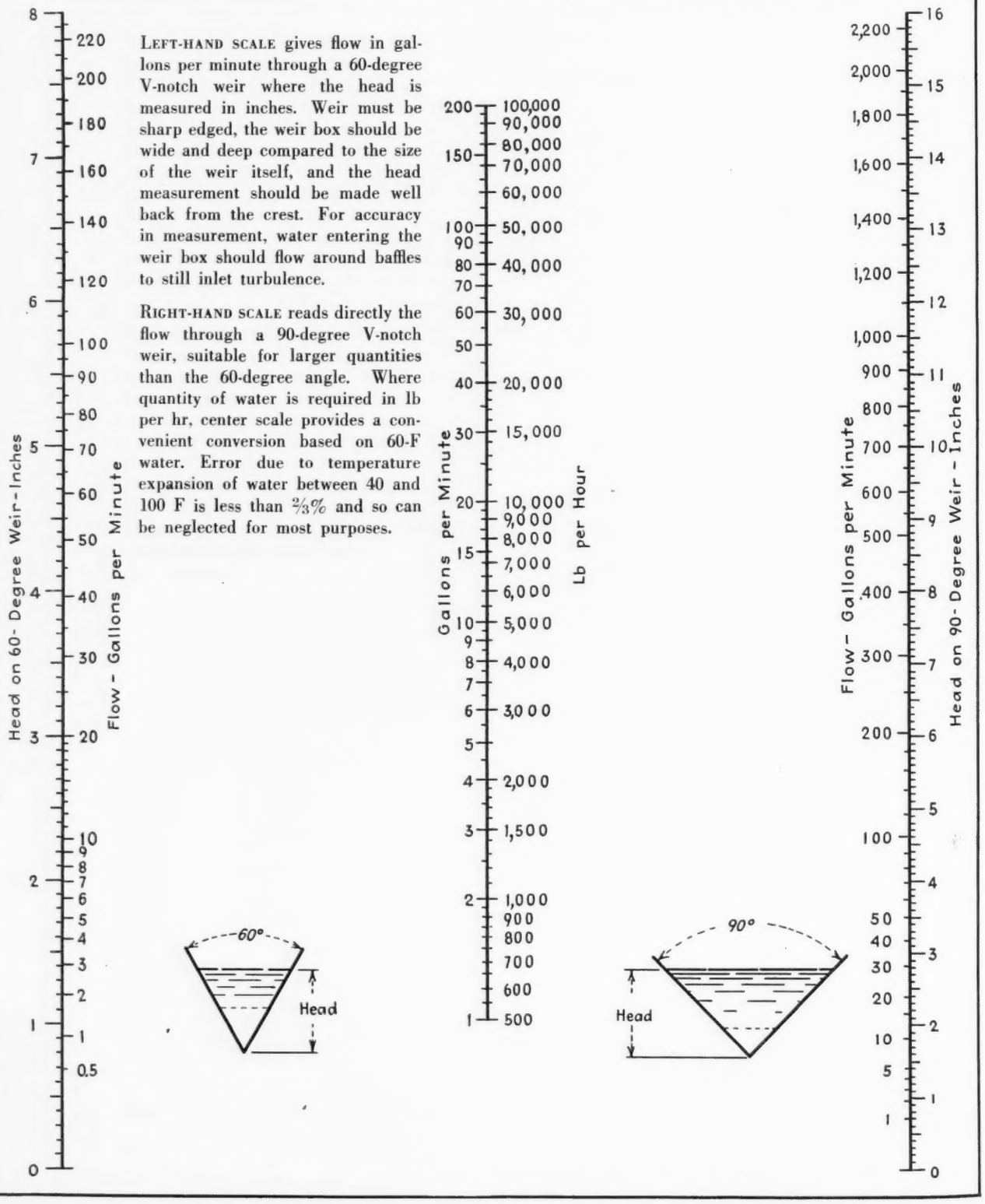
Flow Chart for V-Notch Weir

LEFT-HAND SCALE gives flow in gallons per minute through a 60-degree V-notch weir where the head is measured in inches. Weir must be sharp edged, the weir box should be wide and deep compared to the size of the weir itself, and the head measurement should be made well back from the crest. For accuracy in measurement, water entering the weir box should flow around baffles to still inlet turbulence.

RIGHT-HAND SCALE reads directly the flow through a 90-degree V-notch weir, suitable for larger quantities than the 60-degree angle. Where quantity of water is required in lb per hr, center scale provides a convenient conversion based on 60-F water. Error due to temperature expansion of water between 40 and 100 F is less than ⅔% and so can be neglected for most purposes.



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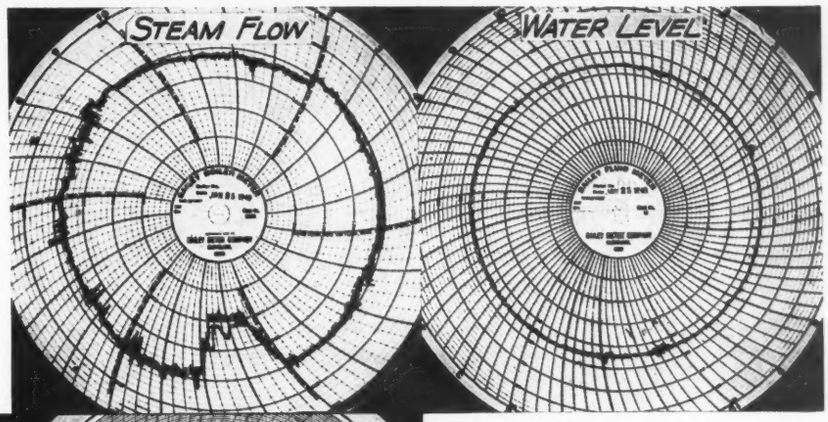
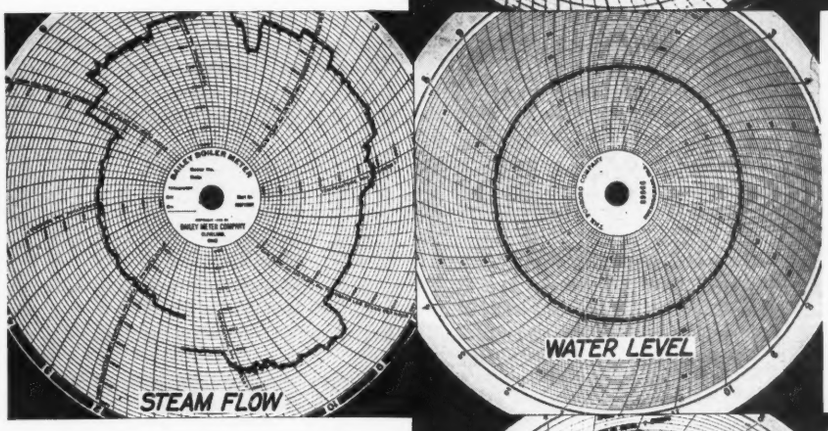
1300 POUNDS W. S. P.—

Fired with pulverized coal or oil, this 1300-pound B. & W. boiler in a prominent Eastern utility plant normally evaporates 275,000 pounds per hour with a maximum of 300,000 pounds. Excess water pressure at pump discharge is 250-300 pounds. The boiler water level is held within plus or minus one inch of the desired normal by the COPES Flowmatic Regulator.



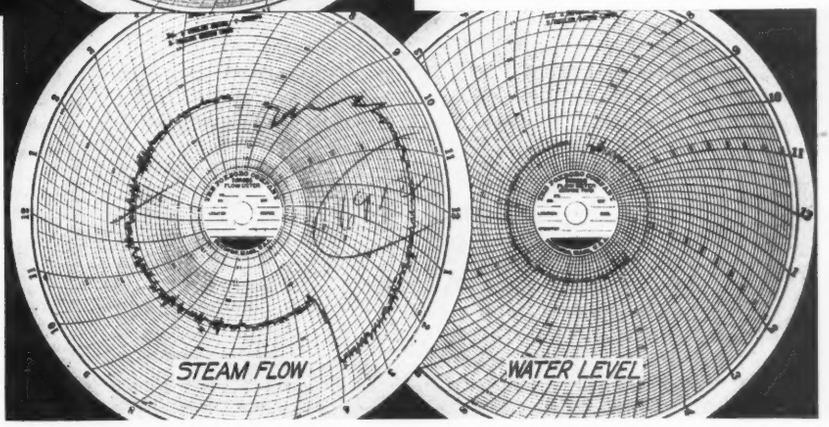


—875 POUNDS W. S. P.

Powdered coal firing. 875-pound, 860-degree, Foster Wheeler 3-drum boiler. The maximum evaporation with this utility boiler is 400,000 pounds per hour; normal, 330,000 pounds per hour. The motor-driven centrifugal pump has no automatic pressure control. Extreme water level range permitted by COPES Flowmatic is 1.6 inches.

600 POUNDS W. S. P.—

Firing with acid sludge or gas, normal evaporation is as high as 350,000 pounds per hour on this 600-pound pressure Riley Steam Generator. Boiler water level is carried one inch higher at peak load of 360,000 pounds per hour than at normal minimum of 242,000 pounds per hour. The level control by COPES Flowmatic is unusually close on all loads.



Why worry about water level?

The COPES Flowmatic is daily demonstrating close level control at pressures from 80 to 1325 pounds—for capacities up to 550,000 pounds per hour. Write for Bulletin 429, showing typical charts and explaining operation.

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New Developments in Lubrication of Gas Engines

► ADVENT OF "packaged" gas-engine power, bringing higher speeds, reduced bore and stroke, and higher compression ratios, introduced new lubrication problems and so made proper oil selection more important than ever, according to the 1940 report of the Gas Engine Power Committee, American Gas Assn. Other features of the report include a census of gas-engine usage showing notable gains since 1936, and details of the high-temperature cooling technique described in POWER, March, 1940.

Ring Sticking No Problem

Unlike diesel lubrication, ring sticking presents no serious problem on gas engines; the principal difficulty lies in controlling the rate of oil thickening. Oils having high chemical stability, good resistance to oxidation, and relatively high viscosity index performed satisfactorily in older type engines but with higher-speed engines the thickening rate seemed to increase rapidly. It has been quite generally believed that this was largely due to reactions between oil and fuel as a result of combustion. Products of incomplete combustion such as soot, carbon and perhaps a heavy oil formed by a combination of the lubricating oil and the fuel hydrocarbons might condense in the cylinders, work past the rings and so reach the crankcase to thicken the lube oil.

The possibility of cracking the lubricating oil was also considered but general experience shows that cracked oil has a tendency to have lower rather than higher viscosity. Considerable research, including fractional distillation tests to determine whether or not heavier fractions had been added to the oil as a result of being in service, brought no conclusive results.

Oxidation and attendant results had been considered a possible cause of thickening; use of recently developed solvent-refined oils with higher viscosity index and higher oxidation resistance gave gratifying improvement. Likewise, use of oxidation inhibitors or deoxidants materially improved the condition.

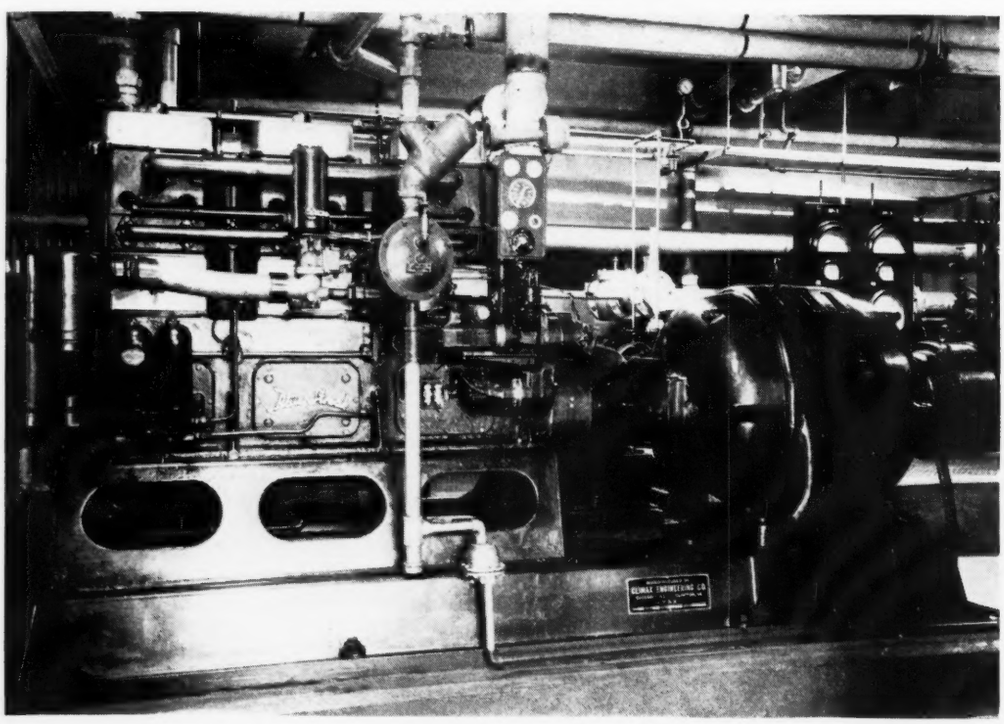
Another factor in oil selection is viscosity; if viscosity is too high a good film will be produced but internal friction of the oil may be excessive; if viscosity is too low, the film may be broken. To be right for the job, oil must have the ability to maintain a proper film under existing conditions of speed, pressure and temperature and the oil must be able to maintain a given viscosity, within narrow limits, for a long period.

It is believed that for high-speed multi-cylinder engines, SAE 30 or SAE 40 oil should be used, depending somewhat on the engine temperature. It is also believed that an oil should not be used after the viscosity has reached 100 Saybolt Universal seconds. For heavy-duty slow-speed engines it is advisable to conform to the recommendations of the engine builder.

Acid-Forming Characteristics

Some oils have characteristics which allow formation of oleic acid, which, although it does not noticeably affect ordinary babbitt, has produced injurious effects on bearings containing a percentage of cadmium or zinc. The result is a dull color with fine pitting. Early bearing failure or marked sludging of oil should call for a check of acidity. Certain inhibitors added to oil will prevent this corrosive action. Bearing manufacturers and oil refiners are now giving serious and careful study to this problem, seeking to prevent acid-caused bearing failures.

Typical modern gas engine driving generator



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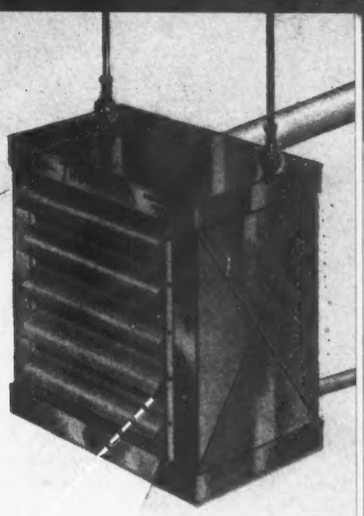
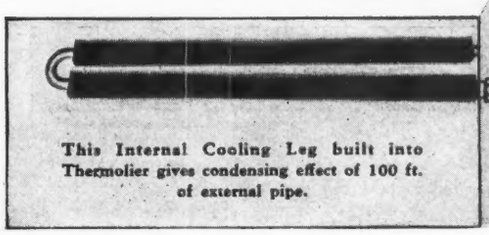
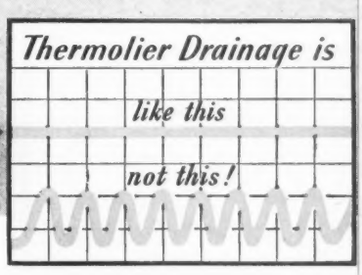


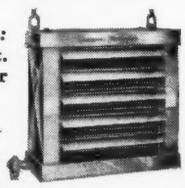


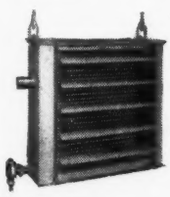
This Internal Cooling Leg built into Thermolier gives condensing effect of 100 ft. of external pipe.



DeLuxe Type: Ideal for showroom or office. All pipe connections, fan and motor, are hidden by the housing. Crackle slate-grey and satin chrome finish.

Industrial Type: For office or plant. Polished copper housing.





Factory Type: In grey Duco, for shops and factories.

More heat per fuel dollar with Thermoliers is made possible by the Internal Cooling Leg which provides continuous drainage of condensate. (In many unit heaters, as much as *one-third* of the tubes is filled intermittently with sluggish condensate.) This superior construction accounts to a major degree for Thermolier's high fuel saving, oftentimes up to 27%.

And this is but one of the 14 points of superiority offered by Thermoliers. In the three types and 37 sizes you will find exactly the unit to fit every requirement. When considering an efficient heating system, let a Grinnell engineer point out why Thermoliers give more heat per fuel dollar. Send for Thermolier Data Book. Grinnell Company, Inc., Executive Offices, Providence, R. I. Branch offices in principal cities of U. S. and Canada.

GRINNELL THERMOLIER

THE UNIT HEATER WITH 14 POINTS OF SUPERIORITY

WHAT'S NEW IN PLANT EQUIPMENT

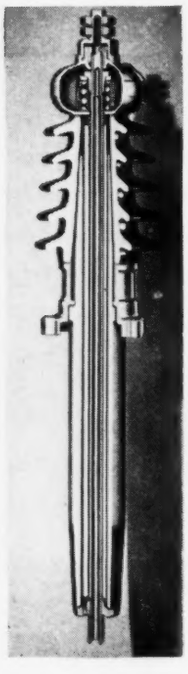
Engine Lubricant

ESSOLUBE HD has been developed to overcome piston varnishing, ring sticking and other lubrication troubles which have limited output of many high-speed diesel and gasoline engines. New lubricant has a viscosity index of approximately 100, nearly twice that previously available in special detergent oils meeting full range of known heavy-duty engine requirements. Lubricant said to have, in addition to other qualities, high ability to wash out sludge deposits, to protect bearings from corrosion and to prevent substantially deposits of varnish on pistons, valve stems, rings, and other engine parts. Essolube HD has been tested, maker says, both in laboratory and on the road. It has passed severe General Motors diesel test, which calls for a 500-hour run in a high-speed diesel under full load and at full speed without oil change. Has also been formally approved by Caterpillar Tractor Co for use in its diesels, passing 1000-hr endurance runs under both laboratory and field conditions. *Standard Oil Co of N. J., 26 Broadway, New York, N. Y.*

Bushings

(below, left)

OIL-FILLED APPARATUS BUSHINGS have been improved by four new features. These are complete sealing, magnetic oil-level indicator, greater use of internal porcelain, and interchangeable terminal system for transformer units. All improvements incorporated without altering design principles of using porcelain as main internal dielectric and using full compression assembly in conjunction with butt-type joints. Illustration shows O-B Class L bushing with quarter-section removed, with new type oil expansion chamber, one type of draw lead terminal and large amount of internal porcelain. *Ohio Brass Mfg Co, Mansfield, Ohio.*



Dust-Proof Oiler

(below, center)

TRICO OILER has removable filter that can be extracted for cleaning without special tools. Oiler is mounted on top of part to be lubricated and any predetermined number of drops of oil per minute can be obtained by needle-valve adjustment. Shut-off lever at top, when in vertical position as shown, feeds oil, and when tilted to side stops flow. *Trico Fuse Mfg Co, 2948 N 5th St, Milwaukee, Wis.*

Transmission Belting

"OCTOPUS" TRANSMISSION BELTING provides greater grip and resilience, according to maker, obtained by new method of combining 24-oz duck with special impregnating material. Requires no belt dressing and is not recommended for oily drives. *Manheim Mfg & Belting Co, Manheim, Pa.*

Flame Control

MERCOID "VISAFLAME" CONTROL is light-actuated mercury switch designed to operate in conjunction with Mercoid safety control panels as power, ignition and flame-failure shut-off for oil burners. Essentially it is gas-filled hermetically sealed glass bulb containing a mercury pool at bottom with one immersed electrode. Other electrode contains two opposing bimetal coils arranged to compensate each other for ambient temperatures. Inner or smaller coil is located in front of concave mirror

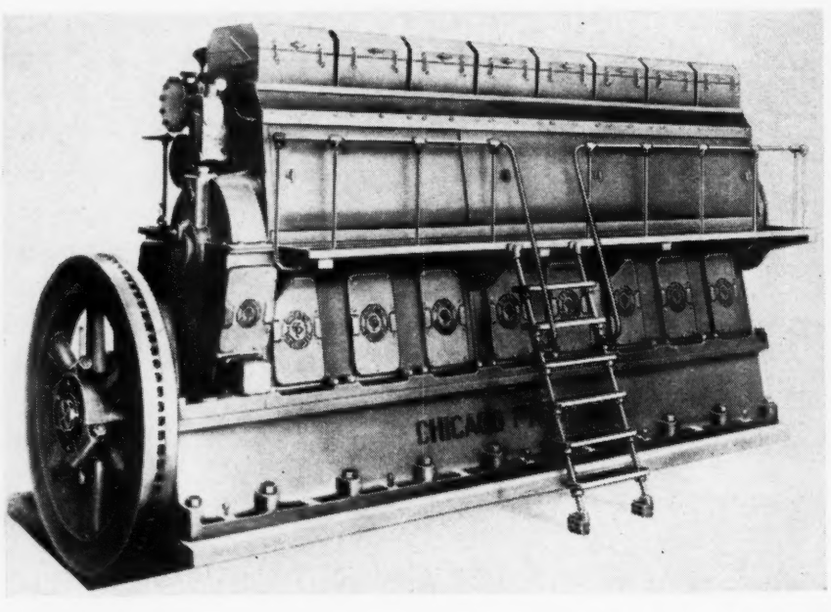
so that when rays from a flame strike mirror they focus on it. Transmutation of light energy into heat causes bimetal coil to rotate and mounted electrode is moved into mercury to complete the circuit. Circuit remains closed in presence of flame, open without it. Combustion-chamber incandescence has no appreciable effect on switch. Device should not be confused with photo-cell actuated switch. *Mercoid Corp, 4201 Belmont Ave, Chicago, Ill.*

Diesel Engine

(below)

TYPE 16 CP DIESEL is 4-cycle, direct-injection type, designed for continuous duty. Available in from 3 to 8 cylinders, from 375 to 1000 hp. Provided with enclosed lubricating system, so no parts of engine require hand oiling. Connecting rods are

(*Continued on page* 140)



INDUSTRY'S CHOICE!

FOR DRIP AND DRAIN LINES

CRANE No. 212-P
PLUG TYPE GLOBE VALVES
(up to 250 pounds, Steam)

For dependable flow control in every service look to the great Crane line of 38,000 valves and fittings. There's a well-stocked Crane Branch or Wholesaler serving every industrial district.

Extra wide seating surface resists wire drawing and erosive effects of foreign matter. Tapered disc of Nickel Alloy permits fine, accurate flow regulation. Seat ring is renewable; of Exelloy, specially hardened to withstand hard wear and temperatures. Body is heavy brass; easily dismantled and re-assembled.

CRANE

VALVES • FITTINGS
PIPE • PLUMBING
HEATING • PUMPS

CRANE CO., GENERAL OFFICES: 836 SOUTH MICHIGAN AVENUE, CHICAGO

How to Be Happy Though Married . . .

"I HEAR they're going to make Tom Fariss general manager", said the grease monkey one afternoon. "Where'd they ever get the idea that a crack salesman knows how to run a plant?"

"Oh, that's a common idea", said Joe. "Somehow they get confused between money-getting and money-spending—and end up by figuring a good salesman ought to make a good manager. Actually, there's no more connection between them than there is between a pretty girl and a good housewife. I'll agree that the pretty girl will get more chances to be a housewife, just like the good salesman gets more chances to be boss. But lots of men find the pretty girls they marry can't run a house—and don't seem to be able to learn—while some plain little wren they wouldn't look at twice turns out to be a crackerjack cook, cleaner and budgeteer.

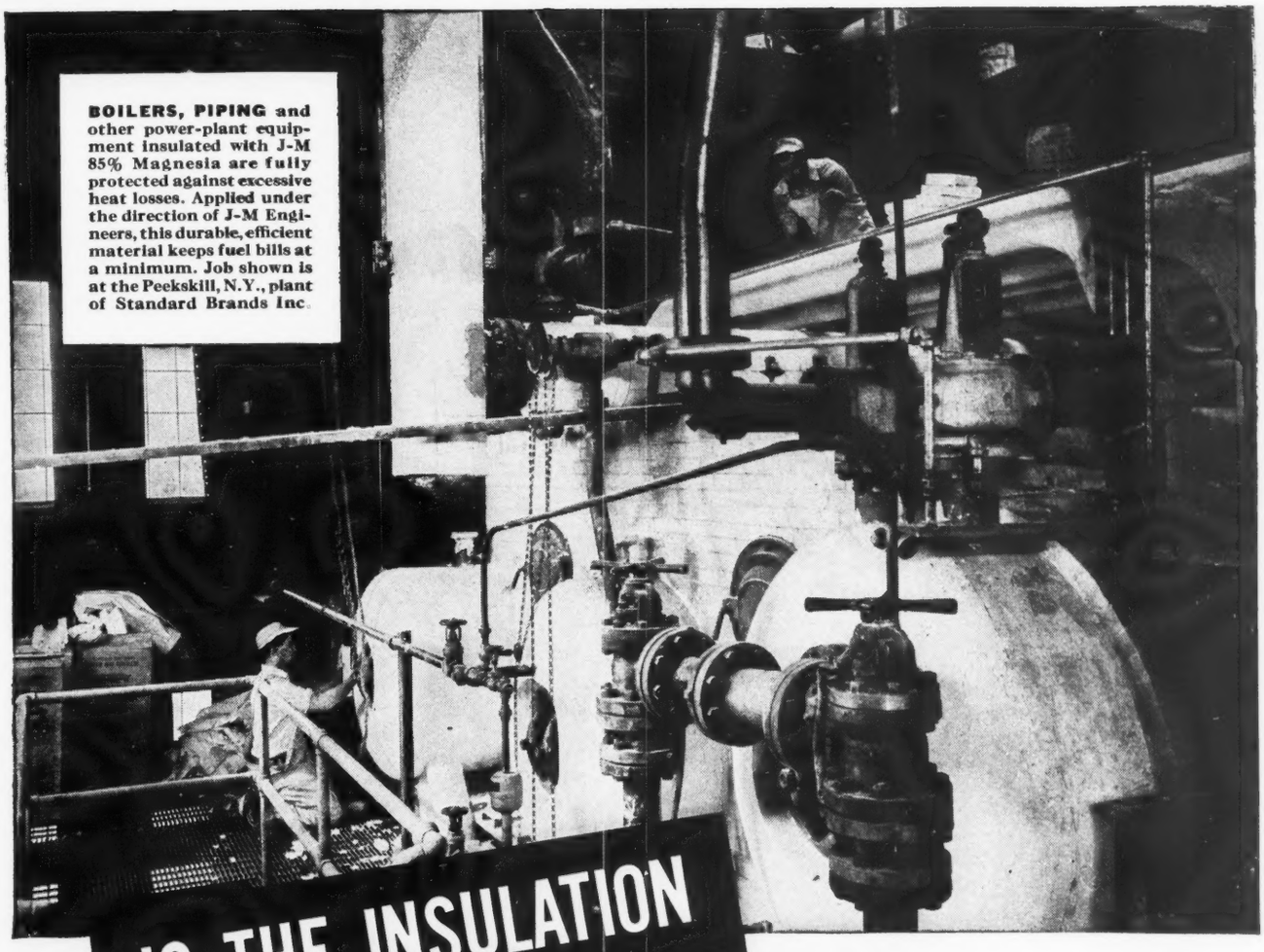
"Mebbe," says Joe, " 'Housekeeper' might be just another word for 'manager'. The good manager is the guy who watches both ends—the income *and* the outgo. He learns to start the needed jobs, and sees that they're finished. He knows how to do a first-class job of housekeeping, including using up the leftovers, staying home from the movies to pay for new dishtowels, and, when necessary, warming the seat of Junior's pants. Yet, come Christmas, he can have a tree, a turkey and all the fixin's—and mebbe even kid the Old Man into playing Santa Claus if the youngsters are good".

I've often thought since about old Joe's principle of management—that a manager is nothing but a good housekeeper—and it has checked out time and time again. Whether it be running a company, a power plant, or a kitchen, first-class housekeeping is essential, and that doesn't mean just keeping the place clean and neat. It includes planning, which means both initiating and following through.

Don't forget that basic idea during the next couple of years—when almost anybody can make a success of any job. Sure as shooting, there'll come a time again when income begins to scale down. Those who have done a good job of housekeeping in the meantime will be all set for the tight times. Those that haven't will go through the usual divorce—between them and their jobs.

George Edwards

Engineer



BOILERS, PIPING and other power-plant equipment insulated with J-M 85% Magnesia are fully protected against excessive heat losses. Applied under the direction of J-M Engineers, this durable, efficient material keeps fuel bills at a minimum. Job shown is at the Peekskill, N.Y., plant of Standard Brands Inc.

IS THE INSULATION IN YOUR PLANT ONLY HALF RIGHT?

ALMOST any insulation will save you some money on fuel. But to get fuel costs down to rock bottom . . . and to keep them there . . . it takes the *one correct insulating material*, applied in the *one most economical thickness*.

To assure every saving possible with insulation, leading power plants rely on the J-M Insulation-Engineering Service. J-M Engineers bring to your plant specialized technical experience and training that enable them to trace down sources of costly heat loss that might otherwise go unnoticed. Because they work with the complete J-M line of insulations, they can recommend the exact amount of the right insulation for your particular problem . . . help you make sure that your insulation investment pays maximum returns.

Whether you are planning on installing new power-plant equipment or interested only in checking heat economy on existing equipment, it will pay you to investigate this free J-M service. For complete information and data on all J-M Industrial Insulations, write for Catalog IN-55A. Johns-Manville, 22 East 40th Street, New York, N. Y.

Johns-Manville INDUSTRIAL INSULATIONS

FOR EVERY TEMPERATURE . . . FOR EVERY SERVICE . . .

Superex . . . 85% Magnesia . . . Asbesto-Sponge Felted . . . Sil-O-Cel . . . Marinite . . . Anti-Sweat . . . Rock Cork

Modern cleaners for modern boiler tubes

In modern boilers there are tubes everywhere, — floor tubes, roof tubes, side-wall tubes, screen tubes, baffle wall tubes, etc. These tubes are full of bends and curves (some on very short radius). Many are quite long (60 to 125 feet). Some are swedged down from one size to another. Several sizes of tubes are used in one boiler.

But modern boilers are like old timers in that the tubes must be cleaned occasionally. We furnish cleaners to the biggest central station plants and for the very latest types of boilers. If a tube is accessible so that a cleaner can be inserted, we can furnish the cleaner which will do the work.

Whether your boilers are up-to-the-minute or twenty-odd years old, Lagonda-Liberty cleaners have the proper types of motors and cutter heads, and the operating hose to do their work well and quickly.

Lagonda-Liberty cleaners are up-to-the-minute in design, and in the use of modern improved metals and heat treating methods. They do a quick and thorough job.

ELLIOTT COMPANY

Lagonda-Liberty Tube Cleaner Dept.

SPRINGFIELD, OHIO

District Offices in Principal Cities

Y-164

LAGONDA LIBERTY TUBE CLEANERS

Gearmotors

(Continued from page 95)

because the high-slip motor can accelerate the load rapidly it may show a considerable higher operating efficiency than a high-efficiency motor with a lower starting torque.

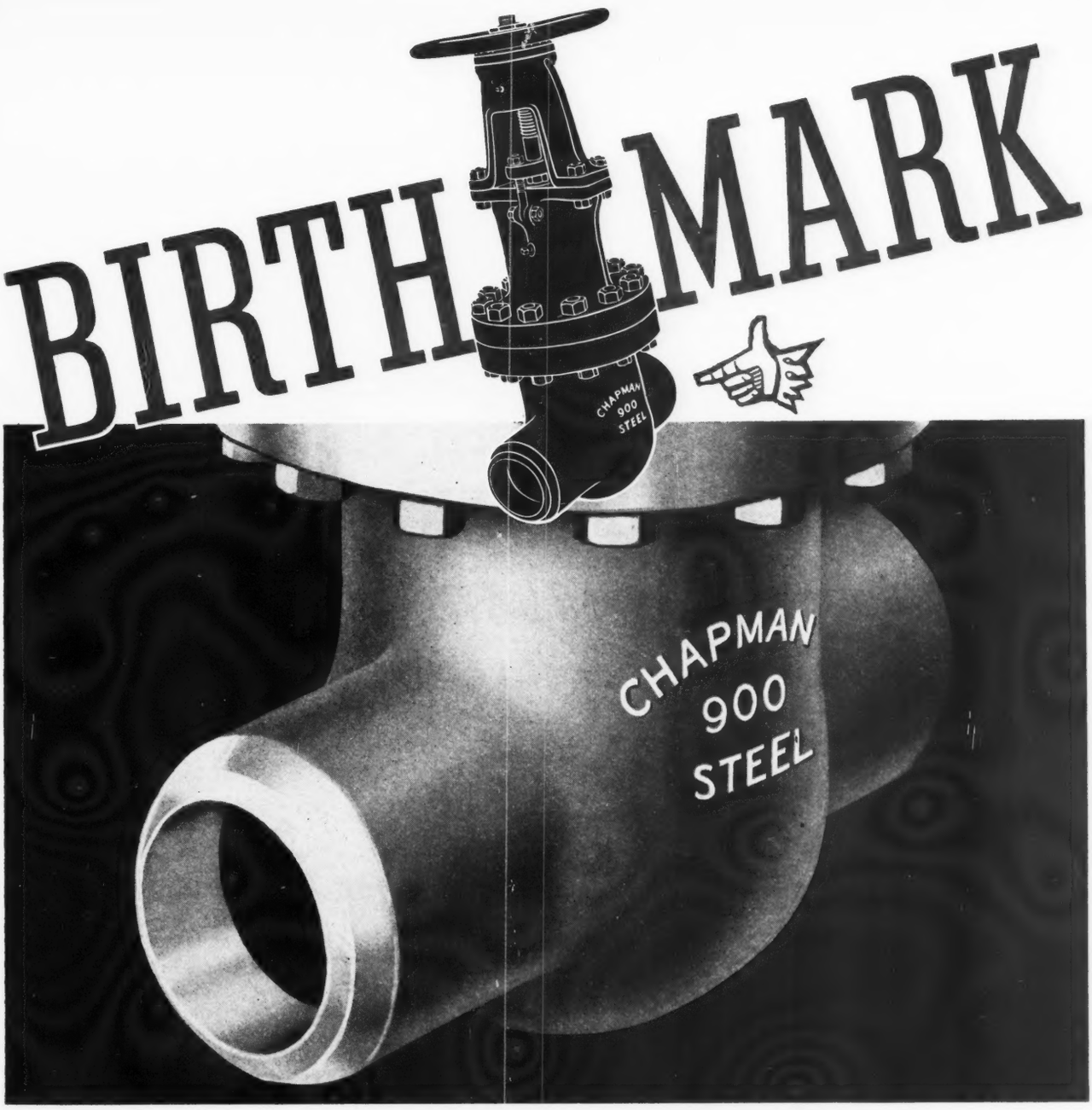
Where starting current must be held to a minimum and starting duty is severe, or where a limited amount of speed adjustment is required the slip-ring gearmotor is used. The latter includes fans, pumps, conveyors and similar equipment. Direct-current gearmotors are also used where only direct-current is available or where wide ranges of speed adjustment are required. Direct-current motors can be built for any reasonable speed, but by using a gearmotor the most economical speed range can be selected for the motor with the gear giving the required speed, all in a compact unit for direct-connection. Where single-phase power only is available, single-phase gearmotors may be had in sizes up to 5 hp.

Multi-Speed Appliances

On some applications, such as ventilating fans, a multiplicity of speed may be sufficient. On such applications multiple-speed gearmotors may be used, see Fig. 6. Here a gearmotor operating at either 1800 or 900 input speed, rated at 4-hp, 115-rpm and 31.5-hp, 230-rpm output speed, is coupled through a free-wheeling clutch to a 300- and 450-rpm motor. This motor, rated 74 hp at 300 rpm and 251 hp at 450-rpm, couples directly to a ventilating-fan shaft. This permits operating the fan at any one of four speeds, 115, 230, 300 and 450 rpm, the lower speeds being obtained with a comparatively low-cost compact direct-connected gearmotor unit.

In general, gearmotors are connected directly to the machine they drive, but they may be connected by belt or chain, as in Figs. 5, 7 and 8. When chain or belt drive is used, provisions must be made to take the overhung load in the gear bearings and on the gearmotor frame. Fig. 7 is a single-reduction unit in which the gear would normally be supported directly from the motor. In this case the output shaft is supported in an extra-heavy bearing and both the gear and motor have feet and are supported on a base plate. This plate is carried on an adjustable base to permit adjusting the slack in the chain. The unit shown in Fig. 8 has a double-reduction gear on which the motor is supported. Here the gear case and gear bearings are made to take the heavy

BIRTH MARK



OF BETTER VALVE PERFORMANCE

All valves, born in the Chapman plant, are indelibly marked "Chapman", in bold letters of steel. And these valves carry this mark proudly through life—a mark recognized in power plants the world over, as the symbol of better valve performance.

The Chapman family is complete. It contains gate, globe, check and angle valves—valves for temperatures to 1000°F. and 2500 lbs. pressure—valves with all types of operating mechanisms—valves in six special steels. Write for the complete Chapman Catalog.

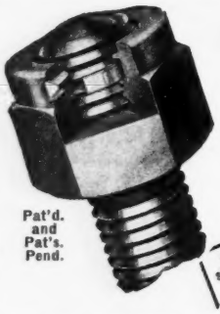
MADE IN THESE ALLOYS

Carbon Steel
Carbon Molybdenum Steel
Chrome Nickel Steel
Chrome Molybdenum Steel
Chrome Nickel Molybdenum Steel

WRITE FOR CATALOG

THE CHAPMAN VALVE MFG. CO., INDIAN ORCHARD, MASSACHUSETTS

CHAPMAN POWER PLANT VALVES



Pat'd. and Pat's. Pend.

Cutout section showing Locking Ring in place

IT GRIPS VIBRATION!

UNSHAKO Self-Locking Nut

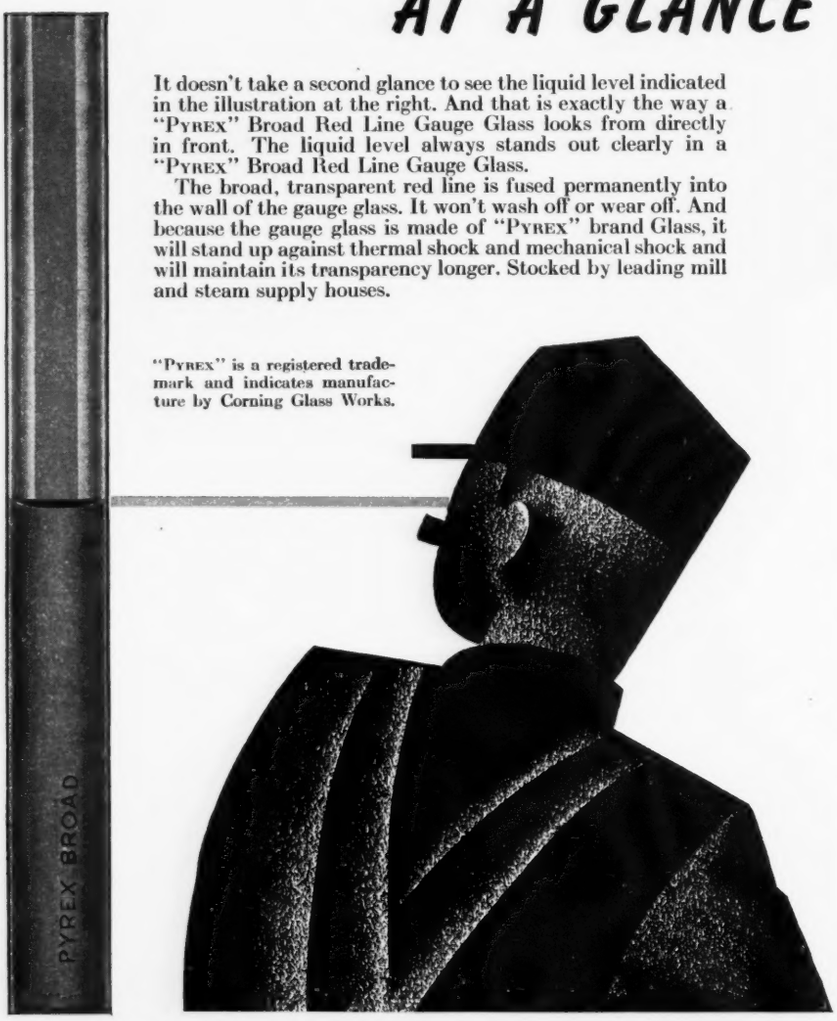
Reg. U. S. Pat. Off.

Here's sure protection . . . inexpensive insurance against the hazard of ordinary nuts working loose: Use "Unshako" on all moving parts of reciprocating engines, pumps, conveyors, generators and stokers. The built-in, self-energizing locking ring is always on guard . . . ready to spring to life and prevent any backing off tendency. *It never fails in its grip!* Does not retard assembly and can be used as long as any standard nut. Write for details.

STANDARD PRESSED STEEL CO.

BOX 577 JENKINTOWN, PENNA.

Visibility AT A GLANCE



It doesn't take a second glance to see the liquid level indicated in the illustration at the right. And that is exactly the way a "PYREX" Broad Red Line Gauge Glass looks from directly in front. The liquid level always stands out clearly in a "PYREX" Broad Red Line Gauge Glass.

The broad, transparent red line is fused permanently into the wall of the gauge glass. It won't wash off or wear off. And because the gauge glass is made of "PYREX" brand Glass, it will stand up against thermal shock and mechanical shock and will maintain its transparency longer. Stocked by leading mill and steam supply houses.

"PYREX" is a registered trademark and indicates manufacture by Corning Glass Works.

CORNING Glass Works Corning, New York

Pyrex Gauge Glasses

overhung load of the 2-strand roller-chain drive.

In Fig. 5 the single-reduction gearmotor is connected to its load by a flat belt. Normally, the gears are supported from the motor, but in this case, to take the overhung load of the belt, a bearing is provided for the outboard end of the shaft beyond the pulley. The gearmotor and the outboard bearing are supported on a common base, which is pivoted so that part of the weight of the gearmotor is used to maintain automatically correct tension in the belt.

Applications of gearmotors cover practically the whole range of standard motors up to 75-hp rating. They may be had in any of the standard types of horizontal or vertical motor frames, such as open, drip-proof, etc.

Argument Corner

(Continued from page 111)

M NIELSEN, *Hartell, Alberta,* reasons it out this way, "Considering the line of admission on one side of the piston and the drop in pressure when the valve opened for admission on the other side, as well as the expansion to below the ordinary exhaust pressure, and assuming there is nothing seriously wrong with the engine or the valve setting, I arrive at the conclusion that the card was taken in a rough sea."

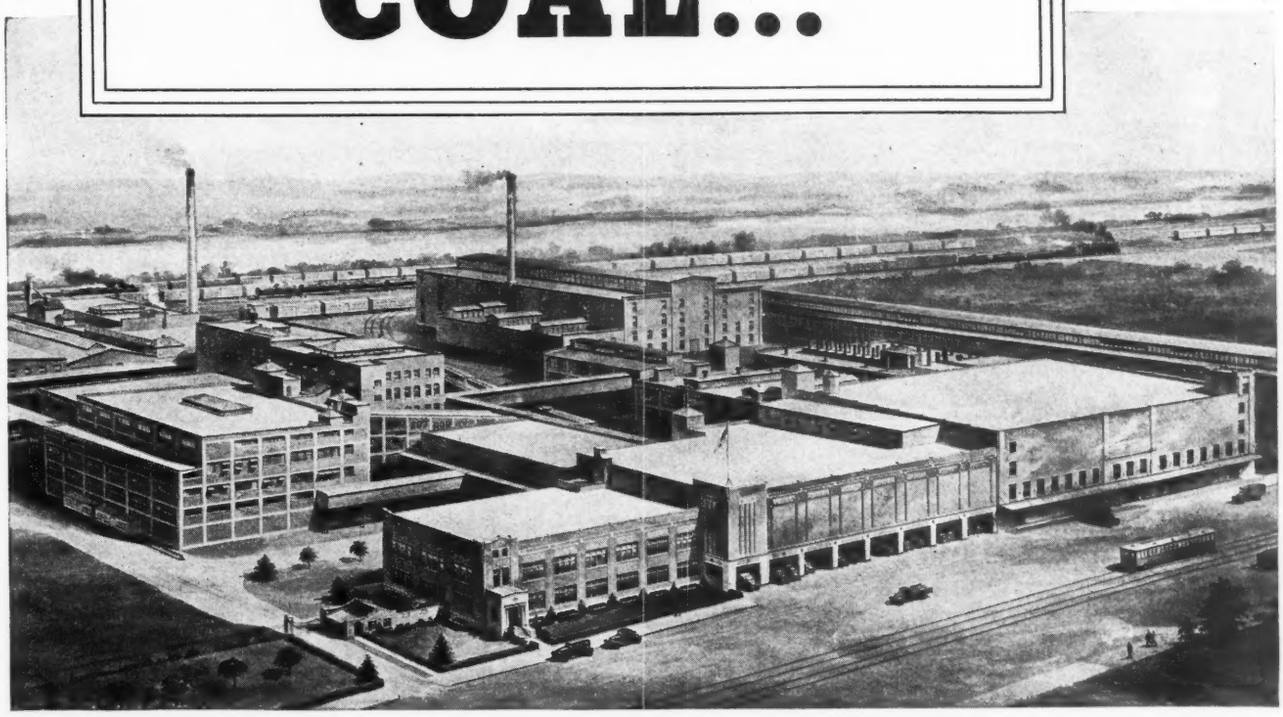
A J LUBELY, *chief engineer, Anheuser-Busch, Inc, Old Bridge, N. J.,* admits to being a firmly grounded landlubber, but comments on the following observation made during a heavy storm aboard an ocean liner:

"Clinging to and looking down over the railing in the very stern of the ship (No, I wasn't seasick), I could see the propellers alternately submerge and rise clear above the water as the ship rode over the mountainous waves. If this occurrence should by chance coincide with the stroke of the engine, I think it would produce precisely the diagram you have illustrated, namely, a heavy load on one stroke and no load on the return stroke."

Q—What is meant by a 14-24 machine screw?

A—The number 14 denotes the diameter. Starting from No. 10, which is equal to 0.19 in., each size number denotes a size increase of 0.026 in. Number 14, which is two sizes above No. 10, would have a maximum outside diameter of 0.242 in.

"OUR PLANT OPERATES 100% ON EFFICIENT, ECONOMICAL COAL"...



. . . say E. Kahn's Sons Co., beef and pork packers of Cincinnati, Ohio.

FROM one of America's most modern plants—E. Kahn's Sons Co., of Cincinnati—comes a complete line of packing house products, headed by the famous AMERICAN BEAUTY hams and bacon. Every heat and power need of this establishment is supplied by modern, prepared COAL burned in modern equipment—at the rate of about 50 tons a day. "We have just placed an order," says Mr. August M. Flick, Plant Engineer, "for an additional 550 h. p. boiler as an auxiliary to our other three. All, of course, burn *coal*, for we consider it the most economical and satisfactory of fuels."

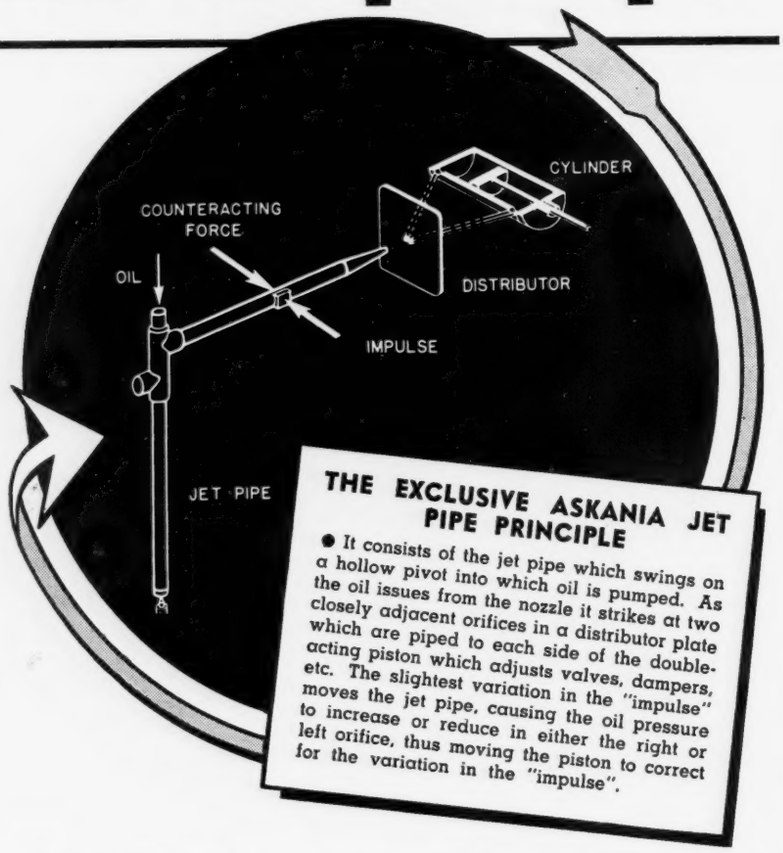
Let our engineers show YOU the way to power economies

Perhaps in your plant there are opportunities to cut fuel and maintenance costs while raising efficiencies and enjoying more dependable power . . . through modern use of modern *coal*. Perhaps Chesapeake and Ohio's Fuel Service Engineers can help you. *It will cost you nothing* to find out. If you'd like our men to survey your plant, confer with your engineers and make recommendations, simply write to GEORGE H. REINBRECHT, Coal Traffic Manager, Chesapeake and Ohio Lines, 2901 Terminal Tower, Cleveland, Ohio. It's well worth a try . . . at no expense to you!

IT PAY$ TO U$E MODERN . . .

Chesapeake and Ohio Lines

Only ASKANIA has this principle



THE EXCLUSIVE ASKANIA JET PIPE PRINCIPLE

● It consists of the jet pipe which swings on a hollow pivot into which oil is pumped. As the oil issues from the nozzle it strikes at two closely adjacent orifices in a distributor plate which are piped to each side of the double-acting piston which adjusts valves, dampers, etc. The slightest variation in the "impulse" moves the jet pipe, causing the oil pressure to increase or reduce in either the right or left orifice, thus moving the piston to correct for the variation in the "impulse".

OBSERVE this jet pipe principle carefully—for it is the gateway to greater sensitivity of control with greater stability, greater dependability and lower maintenance cost than can be achieved in any other way.

The Askania control system uses oil as the operating medium and consequently every part literally "runs in oil". Since oil is incompressible, every adjustment has the power and certainty of hydraulic operation.

Scores of users have praised this certainty of operation. As one user phrases it: "We like the way the control maintains its adjustment day after day — this helps to maintain highest possible operating efficiency."

The jet pipe offers the most simple and direct solution for combustion control problems. Let us explain this exclusive principle in terms of your plant conditions.

ASKANIA CHICAGO

ASKANIA REGULATOR COMPANY
Corner 16th Street and Michigan Avenue, Chicago, Ill.

ASKANIA *Combustion* CONTROL

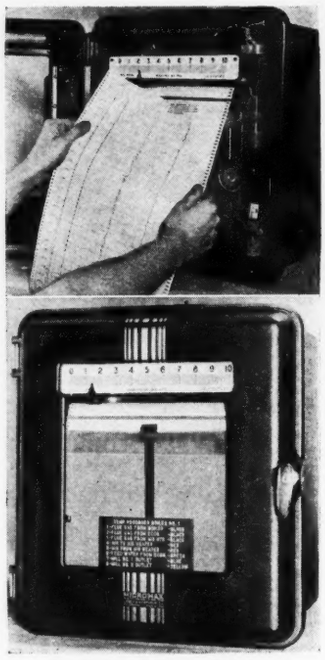
New Plant Equipment

(Continued from page 132)

drop-forged, heat-treated alloy steel, rifle-drilled. Cylinder heads of nickel iron removable without disturbing manifolds, and inlet and exhaust valves are carried in valve cages. Alloy steel used for camshaft construction, which carries cams for inlet, exhaust, starting and fuel pumps. Camshaft driven by silent chain at flywheel end of engine. Camshaft, cam follower, fuel pumps, push rods and air-starter piping completely enclosed, with oil-tight covers permitting easy accessibility. *Chicago Pneumatic Tool Co, 6 East 44th St, New York, N. Y.*

Tear-Off Device

DEVICE ENABLES USERS of Micromax strip-chart recorders to tear off and file record of each day's operation. Made to fit Micromax recorders, device can be attached quickly. When used, there is no wasted



chart, and it is unnecessary to rethread chart through guides. Rubber stamp can be furnished which identifies recorder and location of thermocouples. *Leeds & Northrup Co, 4934 Stenton Ave, Philadelphia, Pa.*

Thickness Gage

MAGNETIC GAGE measures for first time thickness of sheet steel when only one side is accessible. Consists of a 7-lb portable indicating unit, which is connected to an electric outlet, and small cylindrical head containing an alnico magnet. When gage head is placed against material to be measured, permanent magnetic field of head saturates material. How much magnetic flux passes

ALTER EGO: Literally "one's other self"—the still, small voice that questions, inspires and corrects our conscious action.

ALTER EGO: Don't you think mebbe we could relieve the production jam by replacing those old weld jaloppies with NEW welders?

Sure, but then we'd flop right back into a financial jam . . . don't let's spend money.

ALTER EGO: But AREN'T we spending? . . . aren't we spending in excessive welding costs for every welder that isn't of modern design?

Well, they do *claim the new Lincoln is faster.*

ALTER EGO: S'pose it boosts our speed 10%. That'll save us about $200 per year per welder.

Sounds good.

ALTER EGO: And s'pose we increase our speed not 10% but 20% or more—like some Lincoln users have—with Lincoln Welders PLUS Lincoln Service?

That would *be Many Happy Returns on our spending—and we'd be out of the jam in the bargain.* How *do we do it?*

• •

LINCOLN SUGGESTS: Ability to withstand the heavier loads is one reason the New "Shield-Arc" is *faster.* It permits use of larger electrodes. By stepping up electrode size from ¼" to $\frac{5}{16}$", one user increased welding speed 43%—cut cost 25c per pound deposited. What can *you* do? All "Shield-Arc" features are explained in Bulletin 412 (gratis).

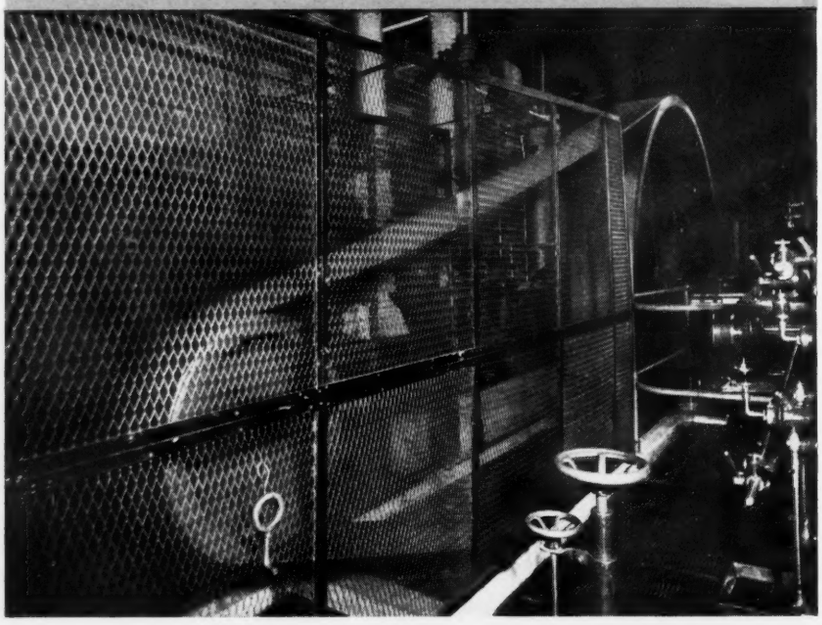
Copyright 1941, The Lincoln Electric Co.

LINCOLN "SHIELD-ARC" WELDING THE LINCOLN ELECTRIC COMPANY Cleveland, Ohio

Largest Manufacturers of Arc Welding Equipment in the World

SAYS THE CHIEF ENGINEER OF A WISCONSIN DAIRY COMPANY:

"Our experience up to date is most satisfactory, and we are looking forward to a good many years of trouble-free service performance from our TANNATE belt!"



THIS *is the performance:*

A 66-8/12′ length of 20″ heavy double TANNATE belting, put in service on a generator in July, 1934, ran until March, 1938, before it had to be shortened. To date, no further take-up has been necessary, and the dairy engineer believes the belt will require no further shortening.

This is what we mean when we say "TANNATE stays on the job with minimum stretch and maintenance." It does! And, its unusual gripping surface transmits *more power* . . . assures maximum machine speeds even at peak loads! (Of this drive the engineer reports, "It has carried our top load without any noticeable effect on the belt or the drive.")

If you are looking for a belting that will increase your production and decrease unit cost and maintenance expense — you'll find it in TANNATE! *Ask for details.*

STEP UP PRODUCTION WITH

RHOADS

Founded 1702

Tannate

WATERSHED LEATHER BELTING

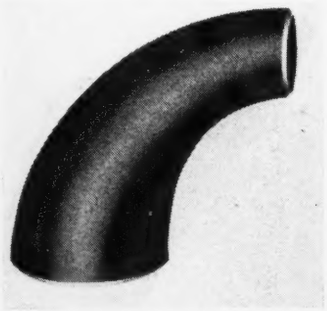
J. E. RHOADS & SONS · 35 N. SIXTH ST., PHILA., PA.

NEW YORK · CHICAGO · ATLANTA · CLEVELAND

through gage head magnetic circuit depends on thickness of material. Thickness is indicated by instrument reading, which is a measure of increased reluctance of magnetic circuit. Thickness of any magnetic sheet or plate material may be measured as long as material is not backed by other magnetic material. *General Electric Co, Schenectady, N. Y.*

Reducing Elbows

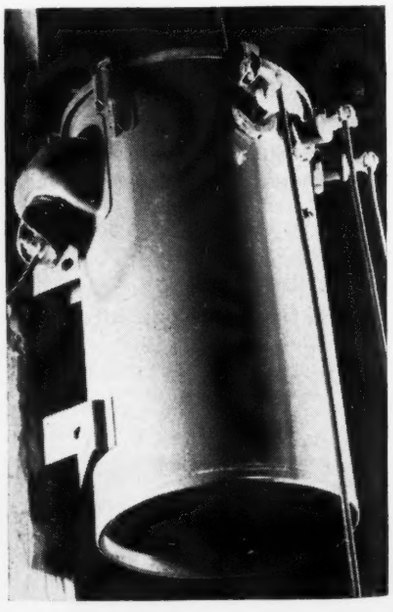
REDUCING BUTT-WELDING ELBOW is used where both direction and size of pipe have to be changed. Formed from one piece of rolled steel plate by special process. Plate is fusion-welded along inner circumference. At this stage, fitting is slightly oversize. Elbow is then reheated and reduced to



accurate size and shape by final working of metal in compression of a forging heat. It is not extruded or stretched. Normalizing both plate and weld relieves stresses set up in forming and welding operations. *Midwest Piping & Supply Co, 1450 South 2nd St, St Louis, Mo.*

Distribution Transformers

TRANSFORMERS ANNOUNCED in accordance with first report of EEI-NEMA committee on standardization. Designed for direct-pole-mounting, new transformers eliminate extra accessories, and standard bushing and hanger arrangements allow interchang-

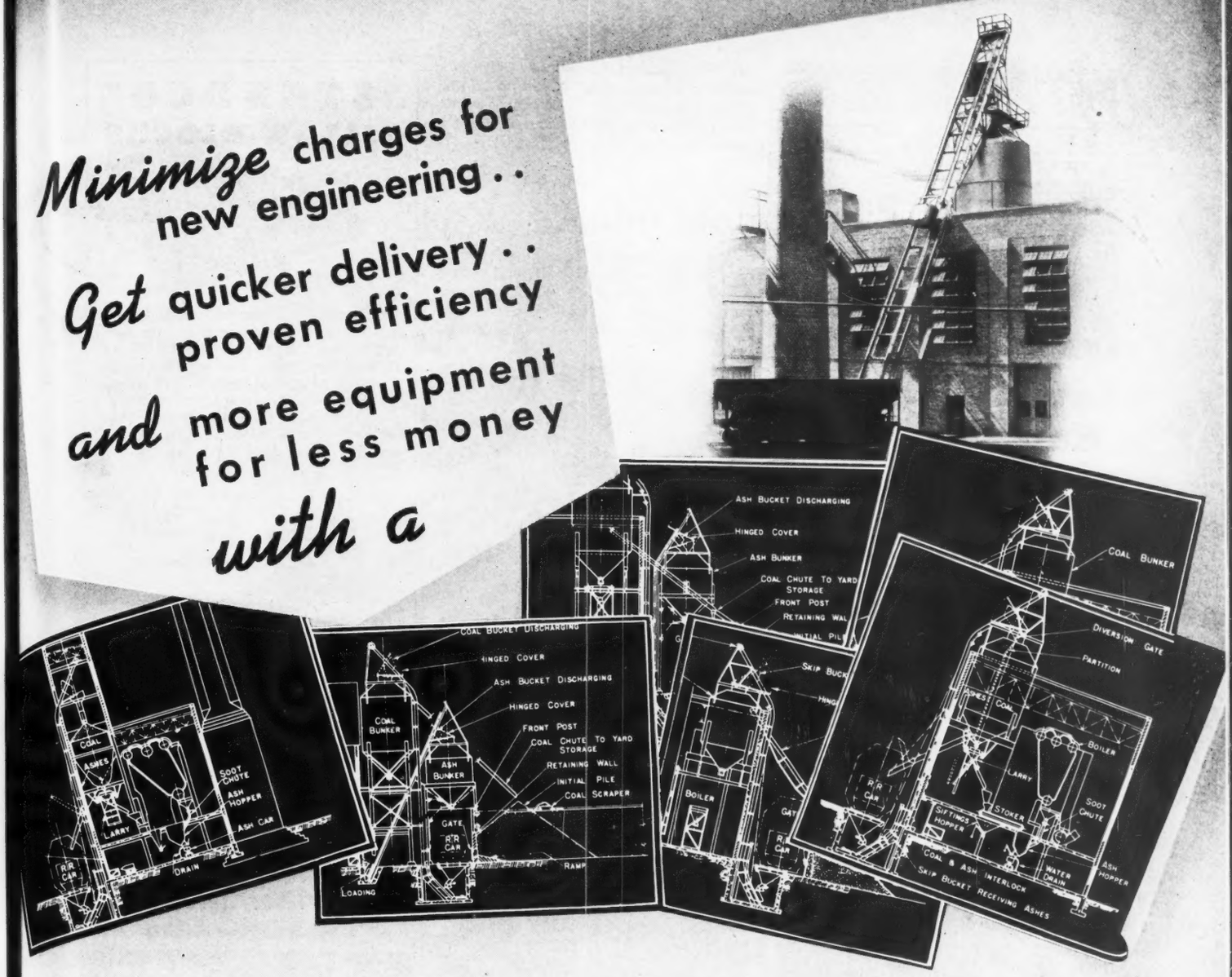


Minimize charges for new engineering . .

Get quicker delivery . . proven efficiency

and more equipment for less money

with a



Bartlett-Snow Standard Coal Handling System

● One or another of the Bartlett-Snow Standard Coal Handling Systems meets exactly the requirements of 90% of boiler plants rated from 1000 to 5000 H.P. Each system consists of track or other receiving hopper, a skip hoist, bunker, weigh larry, and even field storage and ash handling if desired . . . is adapted for installation in existing or new buildings, and can be altered to meet a variety of yard and track conditions. Each represents an actual installation of proven fitness for that size and type of plant, and since they incorporate the use of standard units, they minimize the charges for new engineering—and permit the maximum amount of the appropriation to be expended for actual machinery and plant facilities.

Bartlett-Snow's Coal Handling Systems are being used by consulting and company engineers alike in some of the best known concerns in the country. They have proven their efficiency. Complete details, including engineering diagrams, illustrations, etc., have been reproduced in a 48-page bulletin which will be sent on request to responsible engineers or company officials. It's free. Write for a copy of Bulletin No. 83 today.

THE C. O. BARTLETT & SNOW COMPANY

New York • Chicago • **CLEVELAND, OHIO** • Baltimore • Des Moines

BARTLETT-SNOW

• • BOILER PLANT COAL HANDLING SYSTEMS • •

Complete Engineering and Fabricating Facilities to Meet Any Requirement Including

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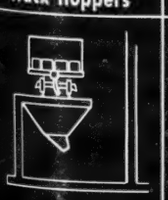	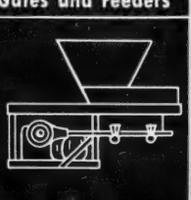		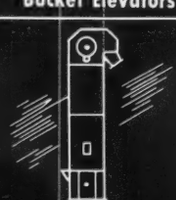		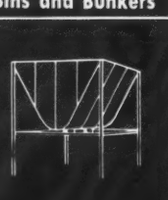	

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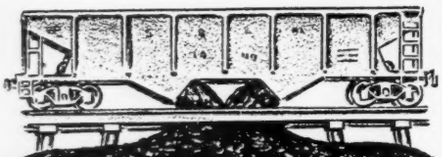
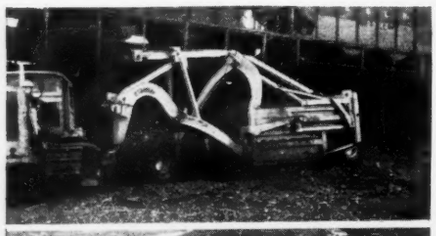
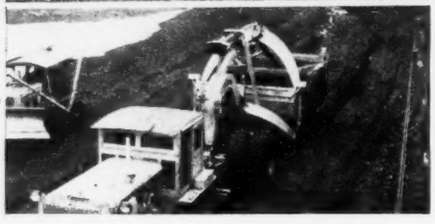


Canadian Firm Banks and Reclaims 300,000 Tons of Coal with LeTourneau Carryalls

Saves Time, Cuts Handling Costs

When heavy gales crumpled its $300,000 coal handling bridge, Dominion Steel and Coal Corporation was storing coal in a bank 40'x1900', thought they might have to abandon it. But a LeTourneau Carryall Scraper and Angledozer with two "Caterpillar" tractors saved the day.





LeTourneau Model W Carryall Scraper and "Caterpillar" D8 tractor pulling away from trestle with a 15-ton load of coal

Coal for the storage bank is dumped from cars through a trestle. The Angledozer snakes this coal out from under the trestle. It is then picked up, carried and spread on the bank in thin, even layers by the Carryall Scraper. On a 200-foot one-way haul, this outfit averaged 19 loads of 15 tons each per hour. Weight of tractor and Scraper traveling over the pile thoroly compacts the coal, thus eliminates flues and prevents spontaneous combustion. The same outfit will be used in the Spring for reclaiming the coal.

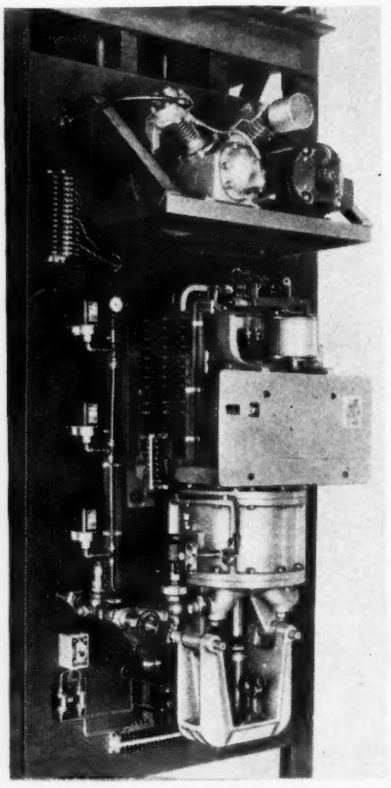
It's a time and money-saving method. Proved by 3 years of use. Ask your LeTourneau-"Caterpillar" dealer to demonstrate its advantages . . . or write TODAY for fact-packed bulletin on the LeTourneau method of coal handling. Address Dept. 4P.

LETOURNEAU
PEORIA, ILLINOIS • STOCKTON, CALIFORNIA

ing of all makes and ratings. Units now available in sizes from 1½-kva to 25-kva, up to and including 15,000 volt class in standard voltages. *Allis-Chalmers Mfg Co, Milwaukee, Wis.*

Breaker Operator

PNEUMATIC OPERATOR for high-speed operation of large outdoor oil circuit breakers consists essentially of air cylinder and piston, and mechanically trip-free mechanism. Uses normal operating pressure range from



80 to 125 lb psi. Auxiliary compressed-air storage tank stores enough air for three closing operations before recharging is necessary. *Allis-Chalmers Mfg Co, Milwaukee, Wis.*

Pulley Cover

WARREN PULLEY COVER is applied to pulleys and V-belt sheaves with brush. Compound dries quickly, giving an adhesive surface which is said to eliminate belt slippage, allow belts to run slack and easy, and reduce wear on belts and journals. *Warren Pulley Cover Co, Danielson, Conn.*

Electrical Porcelain

"PRESTITE" said to have dielectric strength equal to that of wet-process porcelain, mechanical strength about 10% greater under tension and cantilever loads. Since wet-process is not adaptable to production of intricate parts, they are normally formed

(Continued on page 148)

"STANDCO" PILLOW BLOCKS

Fig. 1635

Combining clamp block and pillow block requirements in one type, the "Standco" shown above is sturdily built and is offered in a wide range of sizes. Babbitted bearing surfaces are finished beautifully smooth, both faces machined. It can be depended on for long, trouble-free service.

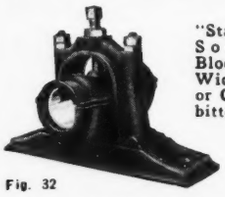


Fig. 32

"Standco" Ball and Socket Pillow Block, Ring or Wick Oiling, Plain or Collar End Babbitted Bearings.

Write for Bulletin

STANDARD PRESSED STEEL CO.
JENKINTOWN, PENNA

Boston, Detroit, Indianapolis — Box 577 — Chicago, St. Louis, San Francisco

BATESGRATES

FILLET WELD

Open Steel Floor Grating

Easily maintained - - -

NO CRACKS, JOINTS, CREVICES

Batesgrates are self-cleaning because of peaked, non-skid cross bar. They have no grooves or rough burned metal to catch grease or dirt. Safe traction. Batesgrates are strictly one piece—no cuts, slots, or punching. Made from Hexagon Shaped Hot Rolled Steel Bars with smoother, larger, much stronger welds. Send today for engineering Catalog No. 937.

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SPECIFY BATES
for long-time economy

WALTER BATES CO.
208 S. LaSalle St. Chicago, Ill.

"MASTER CLEANED"* COMPRESSED AIR

REDUCES { **DELAYS** / **COSTS** / **REPAIRS**

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W-K-M MASTER SCRUBBERS
clean compressed air so that it will not moisten or stain a snow-white handkerchief . . . and do an equally good job on steam and gas.

SELF-CLEANING
NO FILTERS TO
CLOG OR REPLACE

FOR INFORMATION →

BRADSHAW & CO., 530 Fourth Ave., Pittsburgh, Pa.

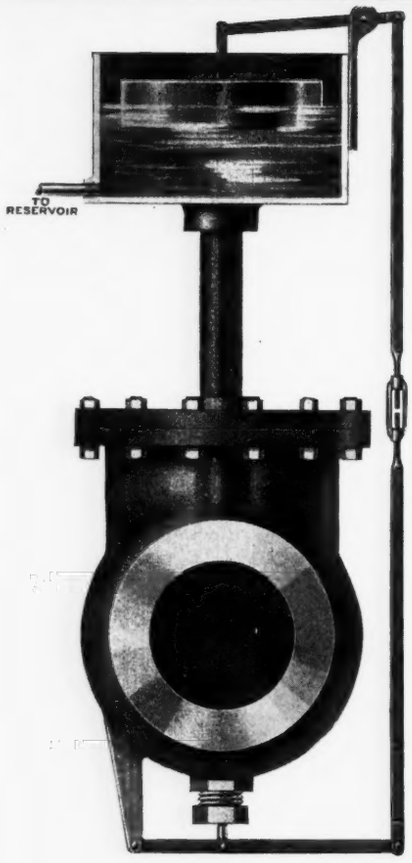
Gentlemen: Without obligation, you may send me the bulletin fully describing the W-K-M Master Scrubber for:
STEAM ____ GAS ____ AIR ____

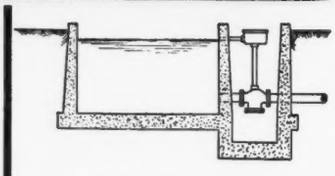
Name ____ Company ____ Address ____ City ____ State ____
(PLEASE PRINT)

Golden-Anderson

SPECIALTY

VALVES





FLOAT CONTROL

● Especially practical and desirable for water level control in mixing chambers, coagulating basins, etc., is the G-A Balanced Controlling Float Valve. It *insures* a maximum water level and a constant rate of flow. In the closed position, this valve will seat absolutely tight, and it is cushioned to overcome any shock or surge. Provided in 3" to 24" sizes, this G-A all-around efficiency valve has flanged ends with iron body and bonnet and bronze trim. Complete and detailed information on the entire G-A line may be had upon request. Write for our latest free catalogs today.

also ***Altitude Control . . . Pressure Reducing . . . Throttle and Emergency Stop . . . Check Valves etc.***

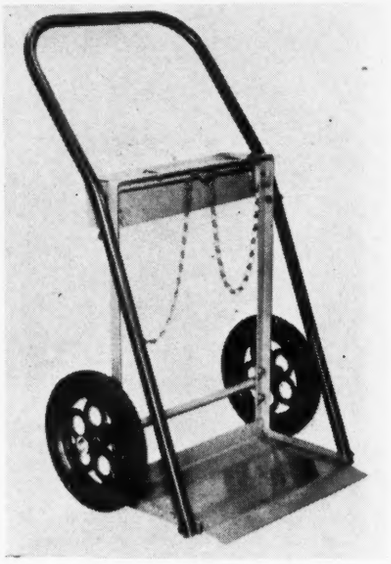
GOLDEN-ANDERSON VALVE SPECIALTY CO.

FULTON BUILDING • • • PITTSBURGH, PA.

by accurate dry process, which is said to yield an electrically and mechanically inferior product. For a given dielectric strength a Prestite part can be made about a third the size of equivalent dry-process piece; for mechanical strength, size reduction varies from about 10 to 30% depending on kind of load carried. *Westinghouse Electric & Mfg Co, East Pittsburgh, Pa.*

Cylinder Truck

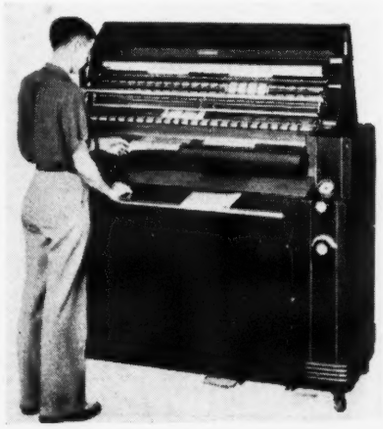
HAND TRUCK DESIGNED to carry oxygen cylinder, acetylene cylinder, and complete welding and cutting outfit. Known as Oxweld T-7, 2-wheel welding truck, unit is



light and balanced, and equipped with semi-pneumatic rubber tires. Removable metal box holds extra blowpipes, tips, goggles, wrenches, etc. *Linde Air Products Co, 30 East 42nd St, New York, N. Y.*

Developing Machine

BRUNING No. 159 volumatic developer is designed for use in conjunction with Bruning printer. Using new combination, one operator performs entire printing and developing operation. Developer consists of separator roll, water roll and series of bands which carry developed prints through dry-



G-E *Hook-on* Instruments Make A-C Measuring Easier

THE G-E hook-on volt-ammeter is the handiest of all instruments for general plant testing—particularly where you need an accurate measurement of circuit conditions in a hurry.

Just hook the AK-1 around a conductor, flick the selector switch to "AMPERES" and you have your measurement. To measure volts, connect the voltage leads, snap the switch to "VOLTS," and take the reading.

ACCESSORIES FOR CONVENIENCE

1. An attractive, black-leather carrying case is available.
2. An extension pole can be supplied for reaching into inaccessible places and for additional protection on high-voltage circuits.
3. Voltage leads are included with each instrument.

AND A LOW-COST HOOK-ON RECORDER FOR CONTINUOUS RECORDS

For trouble investigations and maintenance — where a permanent record of a-c circuits is needed—this G-E hook-on current-measuring set is ideal. It consists of a Type CF-1 recording ammeter and a split-core current transformer.

IT'S INKLESS—ready to go at a moment's notice—no inkwell to fill, no pen to start, and no ink to spill and blur the record.

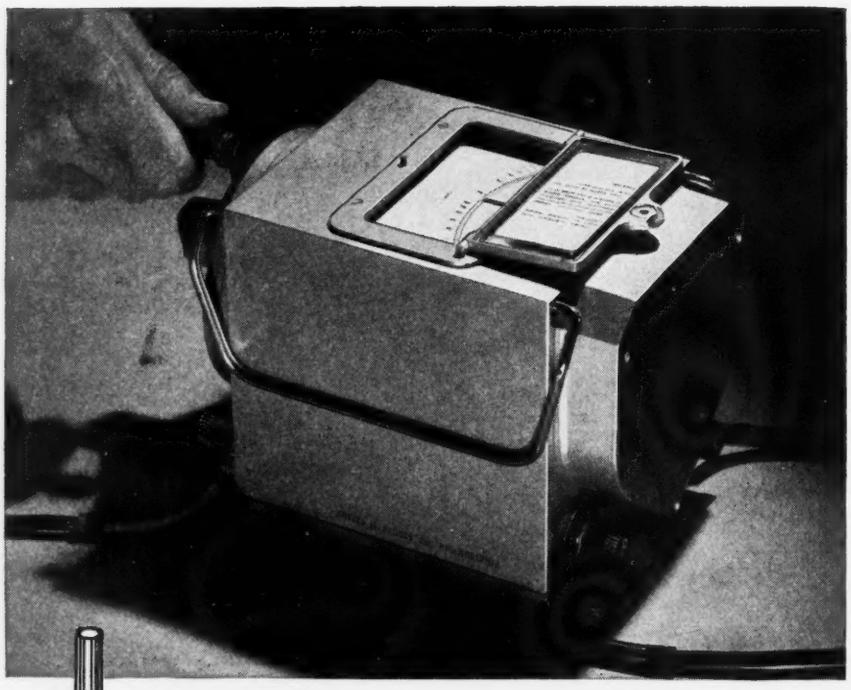
The set is simple to use—just connect the CF-1, close the jaws of the transformer around a conductor, and it starts to record. The instrument operates without attention and has a 30-day chart length. Timing of the chart drive is accurately controlled by a Telechron motor.

Type CF-1 inkless recording voltmeters are also available.

For further information on the hook-on voltammeter, ask for Bulletin GEA-2950; on the recorder, GEA-3187. Your G-E office has copies, or write to General Electric, Schenectady, N. Y.

GENERAL ELECTRIC

602-20



"MEGGER"

TRADE MARK REGISTERED U.S. PAT. OFF.

GROUND TESTER

As simple, rugged and reliable for ground resistance measurements as are our "Megger" instruments for testing insulation.

With ground resistance testing now a recognized necessity for protection against lightning and for safety to human life, we offer a "Megger" Ground Tester that has the desirable characteristics which that well-known name implies.

1. Direct-reading in ohms—"like a voltmeter".
2. No calculations.
3. Only one set of connections.
4. No adjustments or "balancing".
5. Covers a wide range of resistance.
6. Unaffected by stray current in the earth—either a.c. or d.c., or by polarization or electrolysis.
7. Unaffected by the exact resistance of the reference grounds.
8. Has its own hand generator; requires no batteries or other external current supply.
9. Self-contained, rugged and portable.
10. Represents only a small fraction of the cost of adequate grounding protection.

FOR MEASURING RESISTANCE TO EARTH OF ALL TYPES OF ELECTRICAL GROUND CONNECTIONS.

Write for illustrated Catalog 1645-P describing the "Megger" Ground Testing Instruments.

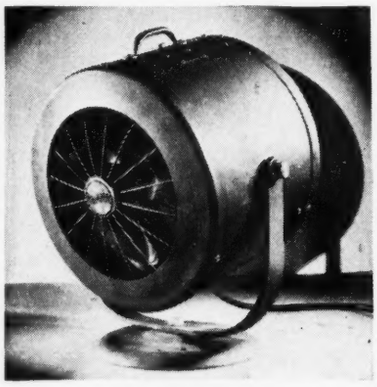
James G. Biddle Co.

1211-13 ARCH STREET *Electrical and Scientific Instruments* PHILADELPHIA, PA.

ing section. Developing section is driven by printer and is synchronized to operate at same printing speeds. *Chas Bruning Co, 100 Reade St, New York, N. Y.*

Electrical Unit Heater

FAN-TYPE ALL-ELECTRIC UNIT HEATER is for year-round use, and available in 2-, 3-, and 4-kw sizes at 115 and 230 volts, ac. Units have output of 7,000, 10,000 and 14,000 Btu per hr respectively. Switch for winter operation controls both heating element and fan, and bimetal thermotat removes motor and heater from line in case of overheating. Fan operates independently for summer use, and baffles direct flow of incoming air over motor to protect it from radiant heat. *Westinghouse Electric & Mfg Co, East Pittsburgh, Pa.*

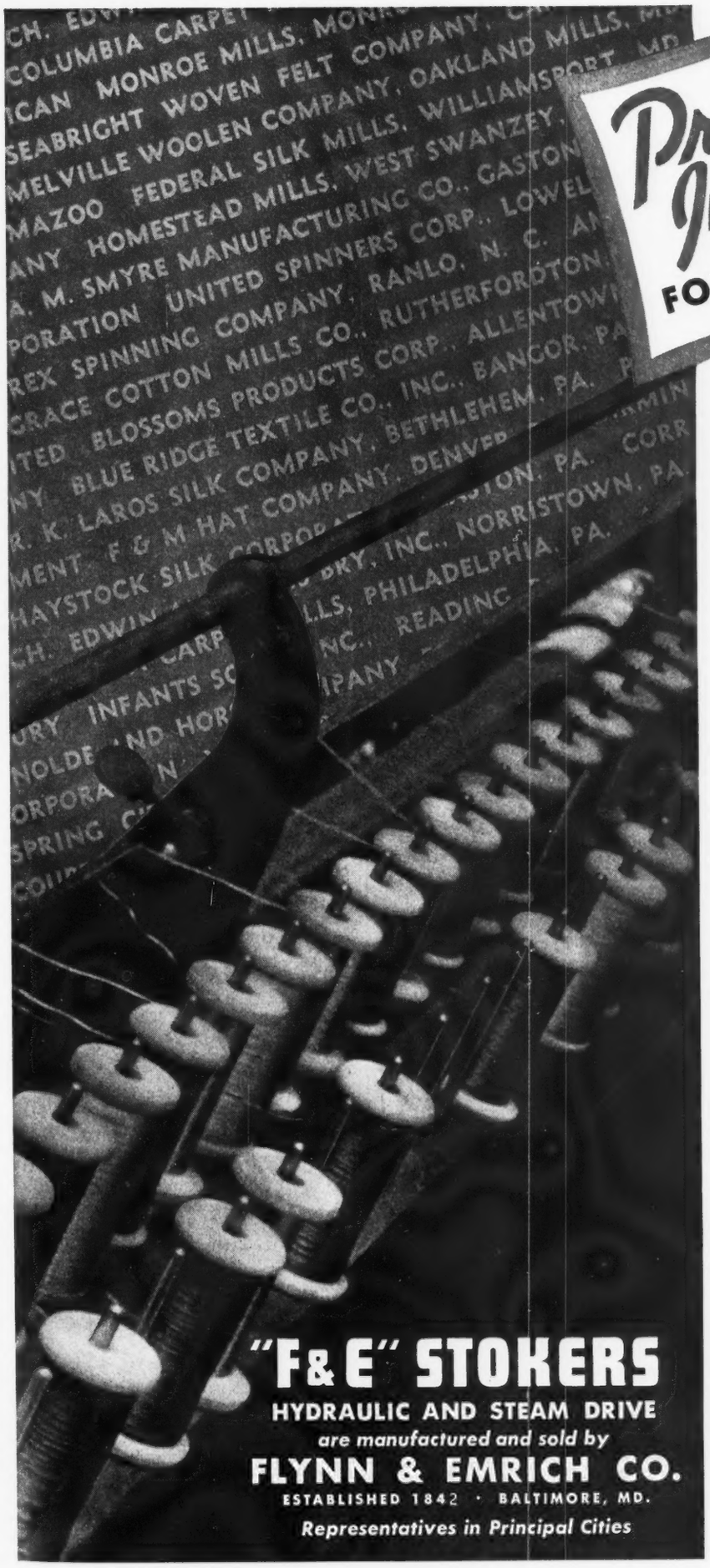


Duplex Tubing

FOR USE IN OIL-REFINING, chemical plants and process industries, duplex tubing solves problems of internal and external corrosion. Is constructed with one type metal on outside and inner tubing of different metal. For example, in oil-refinery work, tubing made of steel outside for corrosive oil vapors and copper inside for circulating fresh water has been found extremely satisfactory; steel outside for same conditions and Admiralty brass inside for circulating salt water. Many other applications and combinations of metal possible, according to maker. *Bridgeport Brass Co, Bridgeport, Conn.*

Voltage Regulator

SILVERSTAT JUNIOR is for automatic voltage control of small ac and dc generators. Regulator performs continuously in automatic, and much quicker manner, the same operation as obtained by hand manipulation of field rheostat of machine under manual control. Voltage of machine to be regulated is connected across regulator coil and any change in voltage results in corresponding change in magnetizing effect of coil on magnetic circuit. Attractive force on an armature will be increased or decreased, causing the armature to seek a new position. This will either close or open in sequence an assembly of silver


COLUMBIA CARPET
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UNITED SPINNERS CORP., LOWELL
REX SPINNING COMPANY, RANLO, N. C.
GRACE COTTON MILLS CO., RUTHERFORDTON
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BLUE RIDGE TEXTILE CO., INC., BANGOR, PA.
R. K. LAROS SILK COMPANY, BETHLEHEM, PA.
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LLS, PHILADELPHIA, PA.
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"F&E" STOKERS
HYDRAULIC AND STEAM DRIVE
are manufactured and sold by
FLYNN & EMRICH CO.
ESTABLISHED 1842 · BALTIMORE, MD.
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Production Insurance FOR TEXTILE MILLS

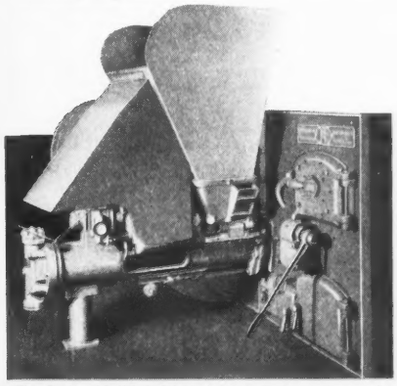
F&E

STOKERS

Rush orders to meet the needs of a nation preparing do not cause undue concern in textile mills whose power plants are equipped with "F & E" Stokers. For they have a *dependable* source of power — secure against breakdowns — capable of operating at peak levels — day in and day out — efficiently and economically.

In no other stoker is found such an array of engineering features that fairly shout "dependability". The patented Interval Timer Governor controls coal feeding rates to almost unbelievable exactness. The Electro-Hydraulic Drive is foolproof. The Retort Sliding Bottom assures perfect underfeed action. The Fuel Bed Regulator permits OUTSIDE adjustment of burning fuel bed. These and other features combine to make "F & E" Stokers the choice of engineers who know that coal-burning equipment is the nerve center of every industry that requires steam for power.

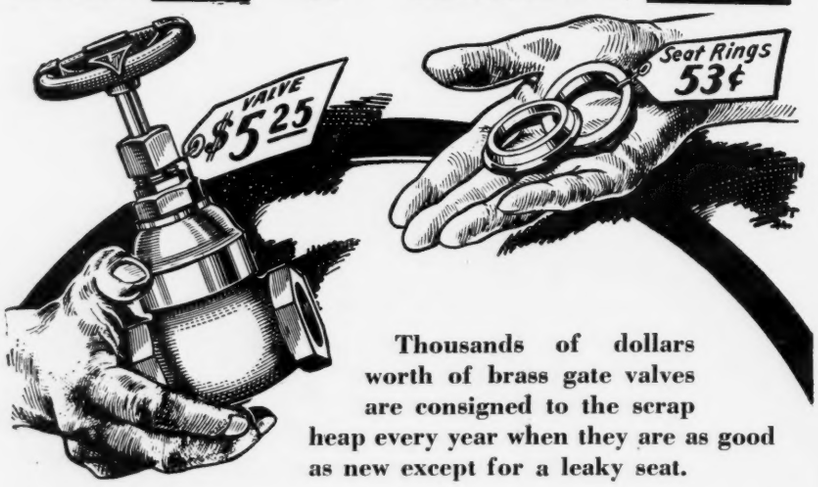
Don't be satisfied with equipment that MAY stand the gaff — specify "F & E" Stokers and be sure! Call the "F & E" Representative in your territory for facts about your plant or see your own consulting engineer.



The Series 60 "F & E" Underfeed Stoker—designed for boilers requiring output ranging from 4000 pounds to 15,000 pounds of steam per hour. Available with steam or electro-hydraulic drive, stationary or moving grates, to suit individual requirements. All types incorporate the desirable Straight Line Ram Action.

Which Would You Rather Buy ?

A New Valve — or — Renewable Seats



Thousands of dollars worth of brass gate valves are consigned to the scrap heap every year when they are as good as new except for a leaky seat.

But it's different with Fairbanks *Renewable* Valves. They eliminate that waste.

Instead of throwing away a Fairbanks "Renewable" Bronze Gate Valve when the seat rings finally become worn, you can quickly slip in new ones—and the valve is as good as new at about 10% of what a new valve would cost. This takes only a few minutes—just long enough to unscrew the bonnet and slip in a new ring. And that can be done without removing the valve from the pipe line.

Contrast this quick, easy and inexpensive renewal with non-renewable valves that have the seats cast integral with the body.

Quick renewal is important when shutting off the steam for a long time means the shutdown of machinery for the same period.

Our valve book No. 21 contains some facts that will interest you. Write for a copy and the name of our nearest distributor.

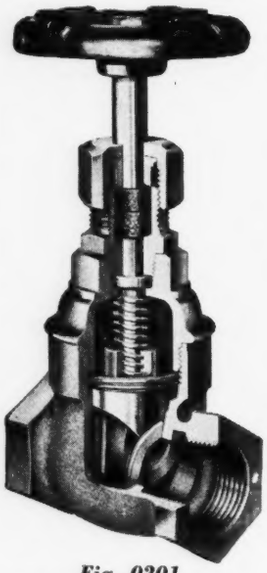


Fig. 0201
150 lbs. steam pressure

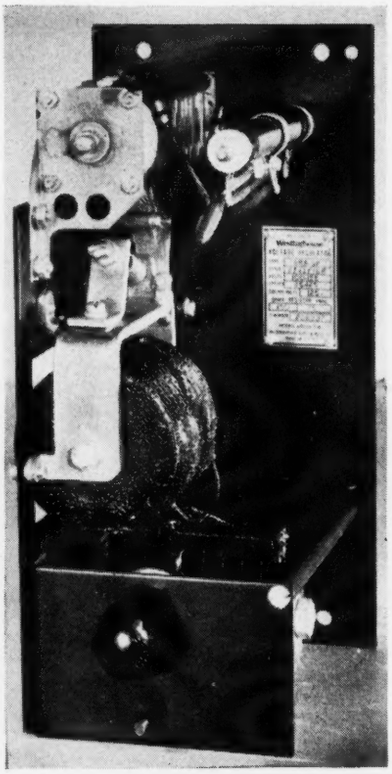
THE FAIRBANKS CO.

397 Lafayette St. New York, N. Y.

Valves, Dart Unions, Hand Trucks and Wheelbarrows

Boston, Mass., Pittsburgh, Pa.
Factories: Binghamton, N. Y., Rome, Ga.

Fairbanks Renewable Valves



buttons to short out or insert steps of a carbon-plate resistor in series with field circuit of generator. This will keep generator output within 3% of normal. *Westinghouse Electric & Mfg Co, East Pittsburgh, Pa.*

Sensitized Metal

PHOTOGRAPHIC SENSITIZED METAL can be used to make contact prints, enlargements, etc, from ordinary drawing, regular print or negative. Aluminum is used as a base, and maker states that usual distortion due to unequal expansion and contraction present in photographic materials is eliminated. No special equipment or treatment is necessary in processing. Manufacturer recommends usual steps of development and fixation followed in processing ordinary film, using standard developer and fixers. Because of its slow speed, metal has additional advantage in that no special darkroom is required. Furnished in sizes 5x7, 8½x11, 11x17 and 22x34 inches, in thicknesses of .006, .008, and .010. *Republic Engineering Products, Inc, 480 Lexington Ave, New York, N. Y.*

V-S Pulley

VARIABLE-SPEED PULLEY is designed for light, inexpensive machinery. Mounts directly on motor shaft and requires only standard V-belts. Features include short overhang, forced lubrication, balanced sheave and all-metal construction. Complete unit includes variable-pitch pulley and adjustable, sliding motor base. By turning base handwheel, motor moves backward or forward causing an increase

Bring that
"INCURABLE" PACKING
PROBLEM
to JOHN CRANE
25 years of "clinical" experience . . . thousands of "cures" are your assurance of solution
RESILIENT
Patented
TAPE-BACKING
"break-proof"
(Illustrated)
SUPER-SEAL PLASTIC
(TAPE-BACK)
★
Newest . . . Super-Seal is an example of John Crane progressive policy of anticipating changing demands! . . . Designed to stand-up to today's peak-loads . . . Plastic types of varying characters to fit required services . . . Dry-graphited: nothing to be squeezed out or drawn-off under pressure . . . Anti-frictional: vulcanizing tape to outer surface prevents fracturing while installing, eliminates friction because only resilient plastic contacts shaft

Processed by

PLUS-PAK

that xxtra which lasts twice as long!

SERVICES:

STEAM superheated and saturated

WATER

AIR & GASES

OILS & PETROLEUM

CHEMICAL-PROCESSING

REFRIGERATION

239 John Crane styles scientifically engineered to specific services . . .

Recommending packings to achieve definite results is parallel to writing a prescription; qualified education is imperative: chemistry, engineering; clinical experience is indispensable. Since there is no valid substitute for these fundamentals engineers will relieve their problems and hedge against reoccurrence by utilizing such technical counsel, especially since John Crane offers consultation without cost. This procedure avoids excessive costs of leakage and shutdown.

☆

P 4-41

CRANE PACKING COMPANY, Chicago, U.S.A.
CRANE PACKING COMPANY, Limited, Hamilton, Ontario, Canada

NAME_____ TITLE_____

ADDRESS_____ COMPANY_____

CITY OR TOWN_____ STATE_____

★ THERE'S A BELMONT PACKING FOR EVERY SERVICE ★

FOR WATER

Now that defense production is taxing plant capacities to the utmost, it's wise to take extra precautions against costly power leaks. Choose Belmont Packings for extra stamina and long-run economy.

Here are practical reasons why Belmont 319 Hollow Center Packing and Belmont 9 Special Hydraulic Packing will properly seal stuffing boxes of heavy hydraulic units such as presses, accumulators, draw-benches, squeezers and pressure pumps:

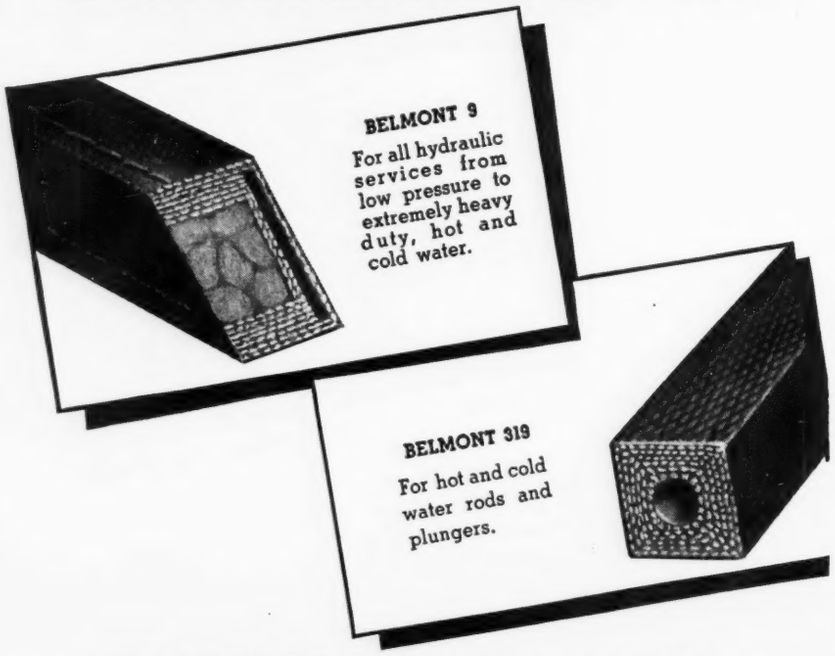
Belmont 319—(rubber and duck). The hollow center provides a point of least resistance for expansion and contraction. Hence, the packing will "breathe" toward the "hole" as varying conditions of service within the stuffing box are exerted upon it.

Belmont 9—(line flax stitched with a rubber-duck channel). This packing combines two distinctive materials made into one integral packing. The rubber-duck channel not only acts as a wiper, but as a protection to the flax. . . . These two packings used in alternate rings make an ideal combination set.

Send for Belmont Catalog No. 40 which illustrates and describes the Belmont Packing line for all services. A request on your company letterhead will receive prompt attention. Any authorized Belmont distributor will gladly show you samples and help you with your particular requirements.

BELMONT PACKINGS

THE BELMONT PACKING & RUBBER CO. — BELMONT — PHILADELPHIA, U.S.A.

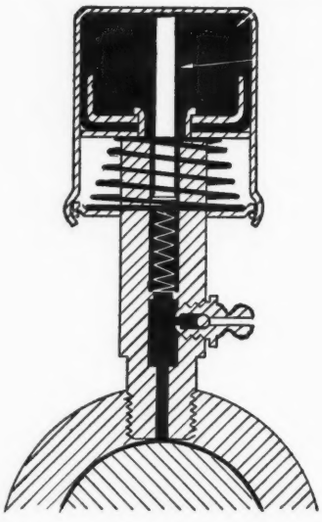

BELMONT 9
For all hydraulic services from low pressure to extremely heavy duty, hot and cold water.
BELMONT 319
For hot and cold water rods and plungers.

THE BELMONT PACKING & RUBBER COMPANY
BUTLER AND SEPVIVA STREETS • PHILADELPHIA, PA.

or decrease in belt tension. This causes pulley to open or close, changing pitch diameter and driven speeds. Pulley faces curved so that belt has full contact at all pitch diameters. Speeds ratios up to 2¾ to 1 available, up to ¾ hp. *Ideal Commutator Dresser Co, 1025 Park Ave, Sycamore, Ill.*

Automatic Lubricator

ACE LUBRICATOR is filled with grease gun and feeds lubricant automatically. Said to eliminate over- or underfilling, shows when refilling is necessary, is self-contained and



can be quickly taken apart for cleaning. By means of adapters, lubricator can be applied to any type bearing where other than standard sleeve bearings are used. *Ace Lubricating Equipment Co, 2345 W Grand Blvd, Detroit, Mich.*

Glass Pump

NASH GLASS PUMP, developed in 1940, now made in smaller size. New pump is ¾x1 in., and has 10 gpm capacity. Like larger pumps, new size is actually constructed of glass, Pyrex brand, and has same advantages of larger pump. Unique mechanical seal replaces conventional stuffing box, and safety unloading device eliminates possibility of fracture of glass casing. *Nash Engineering Co, South Norwalk, Conn.*

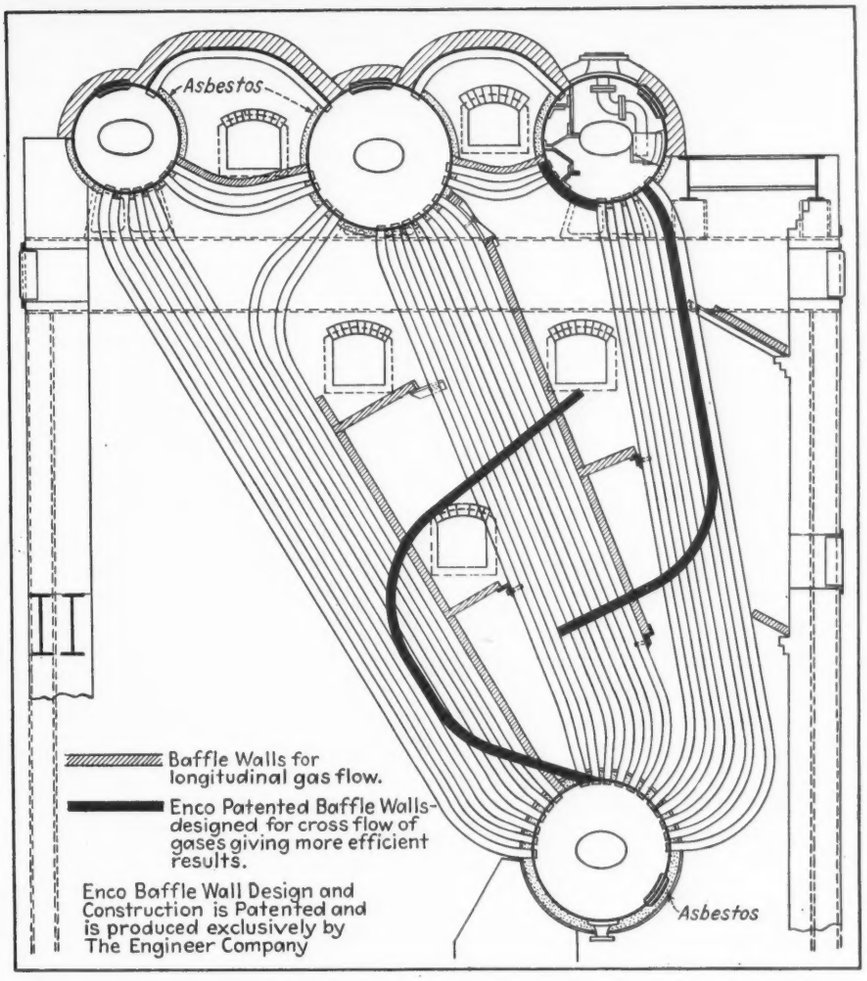
Multi V-Belts

COMPANY ENTERS MULTIPLE V-BELT field with line of standard sizes. Heavy elastic fabric envelope takes up outside wear on

Increase the steam output of your boiler by eliminating the bottle-neck caused by faulty baffle wall design and construction

Enco Patented Streamline Cross Flow Baffles provide a wide open throat into the first pass and quick transit across the first, second and into the third bank of tubes. This assures the quick transfer of the hot gases from the furnace to intimate contact with tube surfaces, maintaining a hot boiler and lower furnace temperature. It also permits a higher steam capacity within flow points of furnace linings.

All gas passages are tapered and reduced in area to conform to the reduction in volume of the gases as they cool in passing over the heating surface. By this method the velocity and the heat transfer are maintained and the draft loss caused by faulty baffle walls having a succession of narrow openings (bottlenecks) is avoided.


Asbestos
Baffle Walls for longitudinal gas flow.
Enco Patented Baffle Walls-designed for cross flow of gases giving more efficient results.
Enco Baffle Wall Design and Construction is Patented and is produced exclusively by The Engineer Company
Asbestos

By Streamlining and Curving the Baffles, a wide flexibility in design to suit various tube and superheater arrangements is possible. Dead gas pockets are eliminated and the entire heating surface is covered more effectively, permitting higher rate of heat transfer.

All Enco Baffles are built gas tight with uniform thickness and smoothly curved surfaces to eliminate angles and avoid eddy currents, promoting the smooth flow of the gases over the heating surface. There are no pockets to collect cinders or fly ash, permitting the soot blowers to work more effectively.

Greater cleanliness of the heating surface increases the output for the same fuel consumption and the reduced use of soot blowers means material saving of live steam.

●

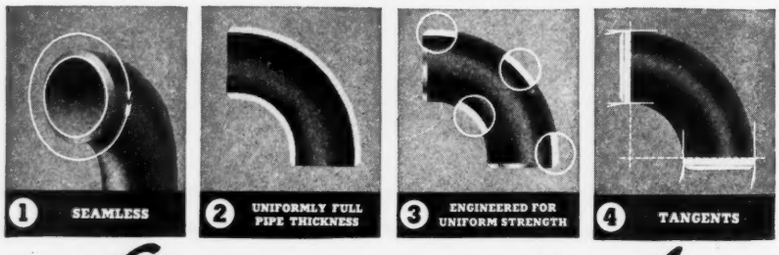
There are many more worthwhile features in the design and Construction of ENCO BAFFLE WALLS for Water Tube Boilers which are described in Bulletin BW-40. Write for your copy.

Enco Patented Cross Flow Baffles are produced exclusively by

THE ENGINEER COMPANY

75 WEST STREET — Enco Streamline Baffles — NEW YORK, N.Y.

TAYLOR FORGE



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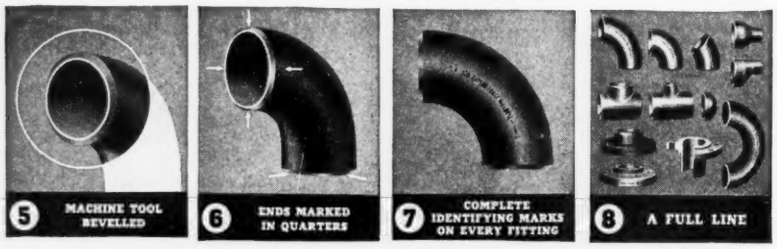
make the acquaintance of the only welding fittings that offer you all these 8 aids to faster, easier welding



WeldELLS

Seamless Pipe Fittings for Welding

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General Offices and Works: Chicago. P. O. Box 485
New York Office: 50 Church St.
Philadelphia Office: Broad Street Station Bldg.

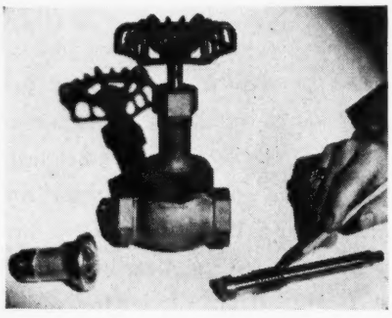
belts, permits ready flexing and holds tightly to groove. Load is carried by cord section of high tensile, low-stretch cords impregnated with liquid rubber, providing lengthwise flexibility and easy flexing around pulley. *Cincinnati Rubber Mfg Co, Cincinnati, Ohio.*

Fire Extinguisher Seals

"GARDESEALS" are bright red trademarked visual signals or handle seals that are destroyed immediately when extinguisher is removed from hook. This tells at a glance whether extinguisher has been inspected or used recently. Easily applied after soaking in water, seals shrink to tight fit in an hour. *Pyrene Mfg Co, 560 Belmont Ave, Newark, N. J.*

Valve-Stem Alloy

"HANCODUR" SELF-LUBRICATING ALLOY developed expressly for use in Hancock "500 Brinell" bronze valves. Maker claims repeated breakdown tests indicate new stems and bonnets outwear other stems and bonnets six times. Also claims that stems made with this alloy have tensile strength of 90,000 lb per inch, plus a high self-lubricating characteristic that resists galling and wear. *Hancock Valve Div, Manning, Maxwell & Moore, Inc, Bridgeport, Conn.*



Cylinder-Boiler Weld

LUSCO CYLINDER-BOILER WELD is now offered in industrial market. Primary purpose is to effect permanent repair of cracks and leaks in boilers, gasoline-engine blocks and circulating systems. Chief ingredient is liquified, concentrated "Weldium", synthetic metallic substance which is deposited on fissure-edge until it has grown together in center. According to manufacturer, substance is non-clogging, non-fermenting, non-separating, odorless, dregless, and uniformly and rapidly dispersive. *C F Lusk Co, 6523 Euclid Ave, Cleveland, Ohio.*

Recording Charts

"PERMOCHART" PLASTIC RECORDING INSTRUMENT CHART is made of non-flammable oil-, gasoline- and grease-resistant plastic, which will not split or curl, and has fibre-reinforced center. In plants where 50 or more

for Meritorious Service in Speeding Greater Defense Production

Marley "Double-Flow" Cooling Towers

INCREASED PLANT CAPACITY *without* COSTLY EXPANSION

Let us cite you numerous cases where the plant management has accomplished exactly that by the simple, low-cost expedient of replacing spray ponds or obsolete, less efficient types of cooling towers with a **Marley "Double-Flow."** The ability to carry heavier loads and maintain better vacuum is paying handsome returns on the investments. In most cases, in fact, improvement has been astonishing even to those most enthusiastic about the likely results when the new cooling tower was being considered . . . For here is a truly superior design in water cooling engineering that adds more KW per dollar of cost than any other kind of cooling tower for large plants—and costs far less to operate, too.

MAY WE SHOW YOU THE RECORDS OF THESE "DOUBLE-FLOWS"?

Please examine interesting, profusely illustrated Bulletin 602 which tells the complete story of this patented, exclusive Marley development. Sent immediately upon request made under your firm's letterhead.

THE MARLEY COMPANY • Fairfax and Marley Roads

Kansas City • Kansas

MARLEY COOLING TOWERS

are saving money and promoting efficiency in plants, smallest to largest, in all types of industries

Schramm Direct Drive Compressor installed "under the stairs" for supplying compressed air service in a well-known plant.

Big Capacity in small, easily installed units

In making this installation of a Schramm Air Compressor advantage has been taken of space in the plant which would hardly have been suitable for large equipment. Yet it is conveniently placed for easy inspection when required.

The compactness of Schramm self-contained compressor units, their smooth, vibration-free performance and light weight eliminate the necessity for heavy, costly foundations. They can be installed quickly in any available location close to where air is needed. They assure a maximum amount of air in a minimum amount of space and at low cost for power.

Schramm Compressors are available in capacities from 25 to 420 cu. ft. per min. for pressures up to 100 lb. per sq. in. direct motor drive, direct engine drive and belt drive types. Send for Bulletin 3907 for complete details.

Capacities of Schramm Air Compressors are rated in terms of the *actual free air delivered* at the discharge valve and not in terms of displacement—an important point to bear in mind when you are figuring your requirements for compressed air service.

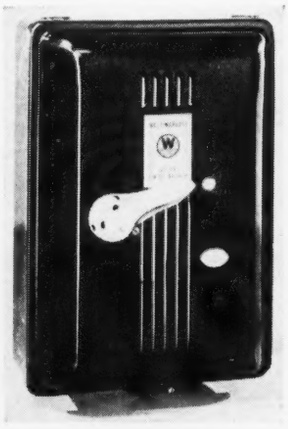
SCHRAMM, INC., WEST CHESTER, PA.

SCHRAMM UTILITY STATIONARY AIR COMPRESSORS

charts are used daily, Permocharts can be used to advantage with Recordak Micro-Filming equipment, maker says. This system gives compact records which can be filed in less space than paper charts as well as cost reduction, according to maker. *Permochart Co, 425 Chestnut Road, Sewickley, Pa.*

Circuit Breaker

DE-ION ENCLOSED CIRCUIT BREAKER is designed for protection of light and power circuits, and is made in four frame sizes, including ratings from 15 to 600 amps in steps corresponding to commercial wire



sizes. Enclosed in water- and dust-tight sheet-steel case, breaker requires mounting space 40% less than for conventional fused safety switches of same ratings, according to manufacturer. *Westinghouse Electric & Mfg Co, East Pittsburgh, Pa.*

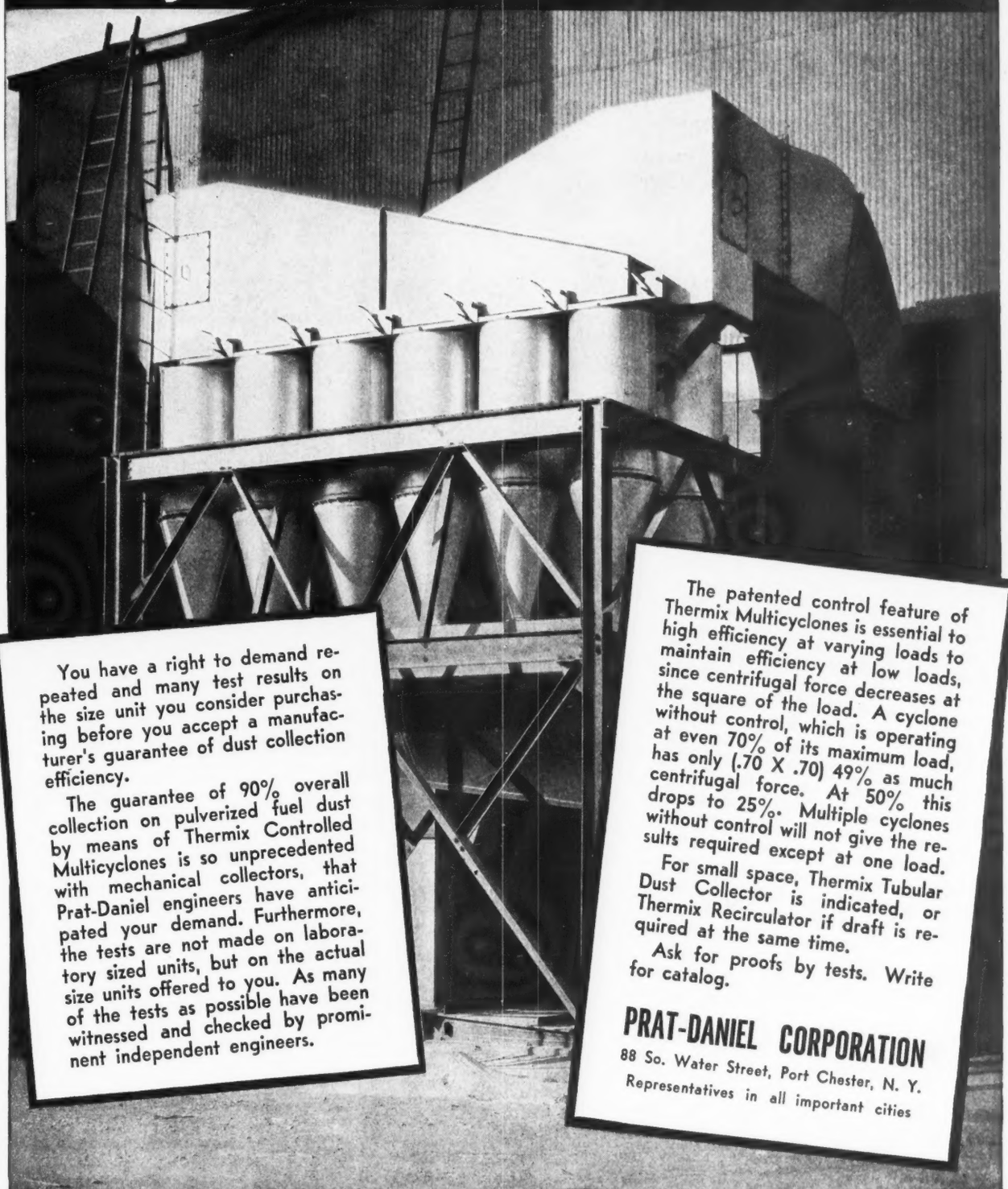
V-Belting

OPEN-END V-BELTING is for application on drives where endless V-belts cannot be applied economically without dismantling a machine to get at sheaves. Belting made in maximum 50-ft lengths, with top widths of $\frac{3}{32}$, $\frac{7}{8}$ and $1\frac{1}{4}$ in., and in thicknesses of $\frac{7}{16}$, $\frac{5}{8}$ and $\frac{3}{4}$ in. Angle in each case is 40 deg. Metal fasteners used for joining belt. *B F Goodrich Co, 460 S Main St, Akron, Ohio.*

Vise Stand

"VISTAND" is balanced and designed for either portable or stationary use. Features of platform include tool notches and slots around the rim, oilcan recess and special "dope" pot. Equipment includes three benders, one for $\frac{3}{4}$-in. pipe, and reverse benders for $\frac{1}{2}$ and $\frac{3}{4}$-in. pipe, placed directly over right front leg to prevent tipping during bending operation. Unit has ceiling brace and feet are punched for attaching to floor, or stand may be used with rubber "shoes" that prevent skidding or scratching. *Armstrong Mfg Co, Bridgeport, Conn.*

Controlled Multicyclones Assure 90% Fly Ash Collection at ALL Loads



You have a right to demand repeated and many test results on the size unit you consider purchasing before you accept a manufacturer's guarantee of dust collection efficiency.

The guarantee of 90% overall collection on pulverized fuel dust by means of Thermix Controlled Multicyclones is so unprecedented with mechanical collectors, that Prat-Daniel engineers have anticipated your demand. Furthermore, the tests are not made on laboratory sized units, but on the actual size units offered to you. As many of the tests as possible have been witnessed and checked by prominent independent engineers.

The patented control feature of Thermix Multicyclones is essential to high efficiency at varying loads to maintain efficiency at low loads, since centrifugal force decreases at the square of the load. A cyclone without control, which is operating at even 70% of its maximum load, has only (.70 X .70) 49% as much centrifugal force. At 50% this drops to 25%. Multiple cyclones without control will not give the results required except at one load.

For small space, Thermix Tubular Dust Collector is indicated, or Thermix Recirculator if draft is required at the same time.

Ask for proofs by tests. Write for catalog.

PRAT-DANIEL CORPORATION

88 So. Water Street, Port Chester, N. Y.

Representatives in all important cities

THERMIX Controlled MULTICYCLONE

"The rockets' red glare gave proof... the flag was still there..."
Baltimore: "By the dawn's early light" just outside Baltimore more than a century ago, Francis Scott Key wrote those immortal words of our national anthem...while all about him a fierce battle raged.
Today, busy Baltimore building owners, managers, and engineers are waging another kind of battle, and winning it, with the help of Macwhyte Special Traction Elevator Cable. It's the "battle" for smooth elevator operation at low-cost-per-car-mile.
PREformed for Better Performance
Now available for an even BETTER fight, is Macwhyte "Hi-Speed" Special Traction, a cable with greater fatigue resistance and much greater flexibility. It helps reduce sheave wear, provides extra-smooth low-cost operation.
Interested in LOW-COST-PER-CAR-MILE? Try Macwhyte "Hi-Speed." It's PREformed for better performance... thoroughly lubricated to give it continuous protection against corrosion and friction. TRY A SET!
MACWHYTE COMPANY • 2944 14th Ave., Kenosha, Wis.
Manufacturers of rope wire—left-&-right lay braided slings—stainless steel wire rope—aircraft cable, aircraft tie-rods, and 'Safe-Lock' swaged terminals—and wire rope to meet every need.
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Try this new technique of heavy lifting. Your loads will be handled safely and easily. Send for literature on ATLAS Braided Wire Rope Slings.
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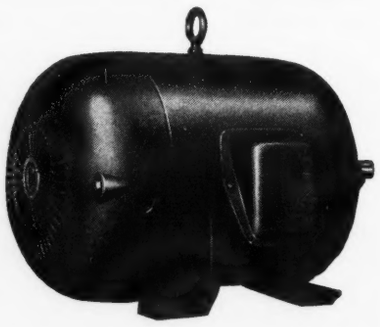
Electric Motors

NEW LINE OF CENTURY ELECTRIC MOTORS provide necessary protection where air is foggy with metal cutting solutions, or where there are abnormal quantities of metallic, abrasive or other dusts in atmosphere that



would ordinarily injure or clog windings on general-purpose open motor. Cooling air is forced through passages by non-sparking fan, and air intake is designed so that $\frac{5}{16}$-in. rod will not pass through screen. *Century Electric Co, 1806-12 Pine St, St Louis, Mo.*

Temperature Relay

TYPE CFT TEMPERATURE RELAY protects machines and transformers against overloading. CFT embodies induction-cylinder design, and supersedes Type ICT induction-disk relay. No change has been made in circuit, says maker, and improved relay still serves as galvanometer in a Wheatstone-bridge circuit comprising resistance temperature-detector in one arm and tapped bridge resistors in three others. *General Electric Co, Schenectady, N. Y.*

Spray Nozzle

"PARASOL" ATOMIZING SPRAY NOZZLE, illustrated, is hollow cone type, with uniform distribution and wide spray angle. Nozzles are of sturdy construction machined with polished orifice insert. Capacities range from 4 to 16 gals per hr at 60 lbs pressure. *Spraying Systems Co, 4021-S W Lake St, Chicago, Ill.*

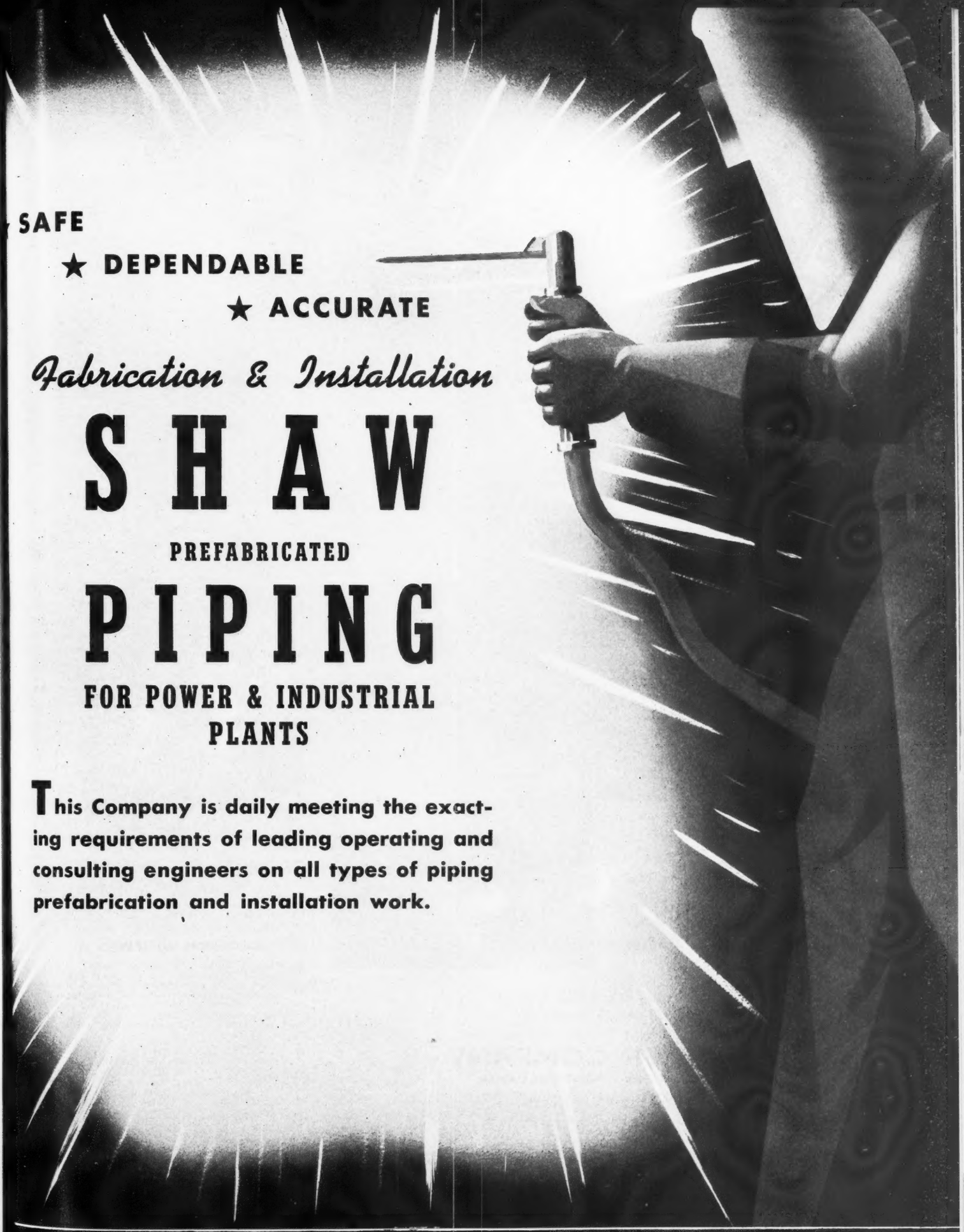
MEETINGS

American Institute of Electrical Engineers—*Summer Convention, June 16–20, 1941, Toronto, Ontario, Canada. H H Henline, national secretary, 33 W 39 St, New York, N. Y.*

American Society of Mechanical Engineers—*Spring Meeting, March 31–April 3, Atlanta, Ga. C E Davies, secretary, 29 W 39 St, New York, N. Y.*

Midwest Power Conference—*Fourth Annual Meeting, Palmer House, Chicago, Ill., April 9–10. Charles N Nash, conference secretary, Illinois Institute of Technology, Chicago, Ill.*

National District Heating Association—*Annual Meeting, June 10 to 13, 1941, William Penn Hotel, Pittsburgh, Pa. John F Collins, Jr, secretary-treasurer, 1231 Grant Bldg, Pittsburgh, Pa.*



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PIPING FABRICATORS AND CONTRACTORS

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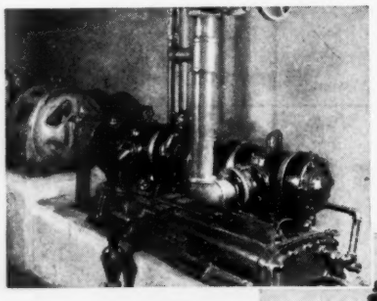
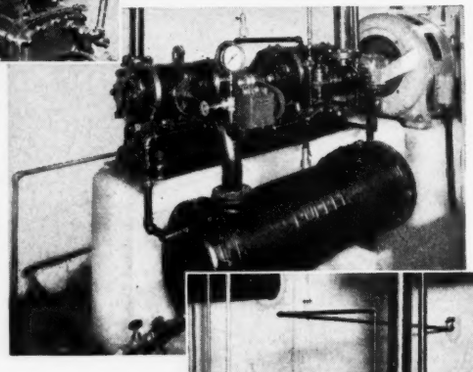
FULLER ROTARY

HEAVY DUTY 100-LB. PRESSURE

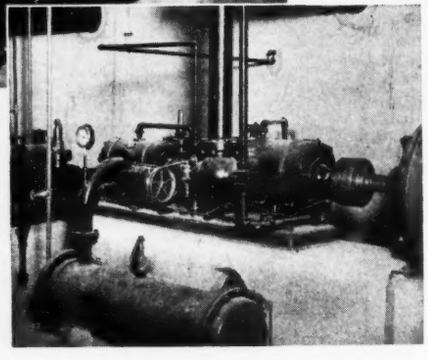
For Heavy-duty, Fuller Rotary Compressors demonstrate their worth . . . available for 80 to 125-lb. service.



Left: **234 C.F.M.** actual free-air delivery, **100-lb. pressure**, Two-stage Rotary Compressor, installed May, 1935, in an incinerator plant in Ohio. No repairs have been made on this machine since being installed. Three Fuller Rotaries are in use at this plant.



Center: **330 C.F.M.** actual free-air delivery, **100-lb. pressure**, Two-stage Rotary Compressor, installed February, 1936, in a foundry in Pennsylvania. This machine furnishes air for general plant duty. The records show expenditures of only $12.00 for repairs, to date. A pertinent factor to be considered when purchasing your next compressor.



Right: **470 C.F.M.** actual free-air delivery, **100-lb. pressure**, Two-stage Rotary Compressor, installed 1938, in a cement plant, for general plant duty. Three Fullers are installed in this plant.

Write for Bulletin C-3A

FULLER COMPANY
CATASAUQUA, PENNSYLVANIA

Chicago: 1118 Marquette Bldg.
San Francisco: 320-321 Chancery Bldg.

C-52

Fuller

FULLER-KINYON, FLUXO, AND AIRVEYOR CONVEYING SYSTEMS
ROTARY AIR COMPRESSORS AND VACUUM PUMPS
ROTARY FEEDERS AND DISCHARGE GATES
AIR-QUENCHING COOLERS BIN SIGNALS

New Bulletins

BOILERS AND ACCESSORIES

1 HRT BOILER—Combustion Engineering Co, Inc, 200 Madison Ave, New York, N. Y. Catalog No. HRT-11 gives details of design and construction of horizontal return tubular boilers, contains various setting drawings and tables of standard dimensions for both brick-set and steel encased settings. Different methods of firing shown and installations illustrated.

2 ASBESTOS—Keasbey & Mattison, Butler Pike, Ambler, Pa. 32-page illustrated catalog covers K & M "Century" asbestos corrugated for building construction. Advantages and applications included, together with specifications of main sections and accessories.

3 FIREBRICK—Armstrong Cork Co, Lancaster, Pa. 8-page booklet describes Armstrong insulating firebrick, five types for temperatures to 2600 F. Paragraphs cover each type of brick.

4 COAL CRUSHER—American Pulverizer Co, 1249 Macklind Ave, St. Louis, Mo. 8-page folder shows operation and points out advantages of American ring crusher. Shows how crusher is constructed and gives comparisons between coal crushed by ring and roll crushers.

5 BOILERS—National Radiator Co, 221 Central Ave, Johnstown, Pa. 64-page 1941 catalog illustrates and gives data on boilers and units for all fuels, with all information classified under types and sizes of boilers. Ratings and data on radiators, convectors, enclosures and hot-water heaters given.

6 BOILER EQUIPMENT—Permutit Co, 330 West 42nd St, New York, N. Y. 8-page bulletin No. 2391 covers Permutit automatic continuous boiler-blowoff equipment. Tells why blowoff is necessary, points out shortcomings of old or intermittent controls and discusses several typical arrangements of modern continuous blowoff systems based on flash or non-flash, high or low heat level, single- or group-control operating characteristics.

6A HEAT EXCHANGERS—Alco Products Div, American Locomotive Co, 30 Church St, New York, N. Y. 4-page bulletin No. 1023 describes Alco heat exchangers, prefabricated piping and pressure vessels. Explains Alco triple-service.

7 STOKER—American Coal Burner Co, 155 East Superior St, Chicago, Ill. 8-page folder illustrates, points out advantages of and describes "Fyr-Feeder" stoker. Line drawings show essential parts, and principle of operation explained.

7A GAS BURNER—Lee B Mettler Co, 406 S Main St, Los Angeles, Calif. 4-page illustrated bulletin F-2 describes automatic "entrained combustion" motorized fan gas burner assembly, with applications and mechanical and capacity details.

ELECTRICAL EQUIPMENT

8 ELECTRICAL CONNECTORS — Burndy Engrg Co, Inc, 459 East 133rd St, New York, N. Y. 64-page data book No. 41 describes complete line of solderless electrical connectors for cable, flat-bar and tubular conductors and gives technical data on insulated cable and flat copper bars.

9 SWITCHGEAR—General Electric Co, Schenectady, N. Y. GEA-2499A gives most important facts about G-E master metal-clad switchgear, telling how to remove breakers, how mechanical interlock works and how other parts operate.

10 PHOTOMETER—Leeds & Northrup Co, 4934 Stenton Ave, Philadelphia, Pa. 20-page catalog E-72 describes entire line of photometers, used for testing lamps, making lighting surveys, photometric research and in laboratories.

AIR CONDITIONING

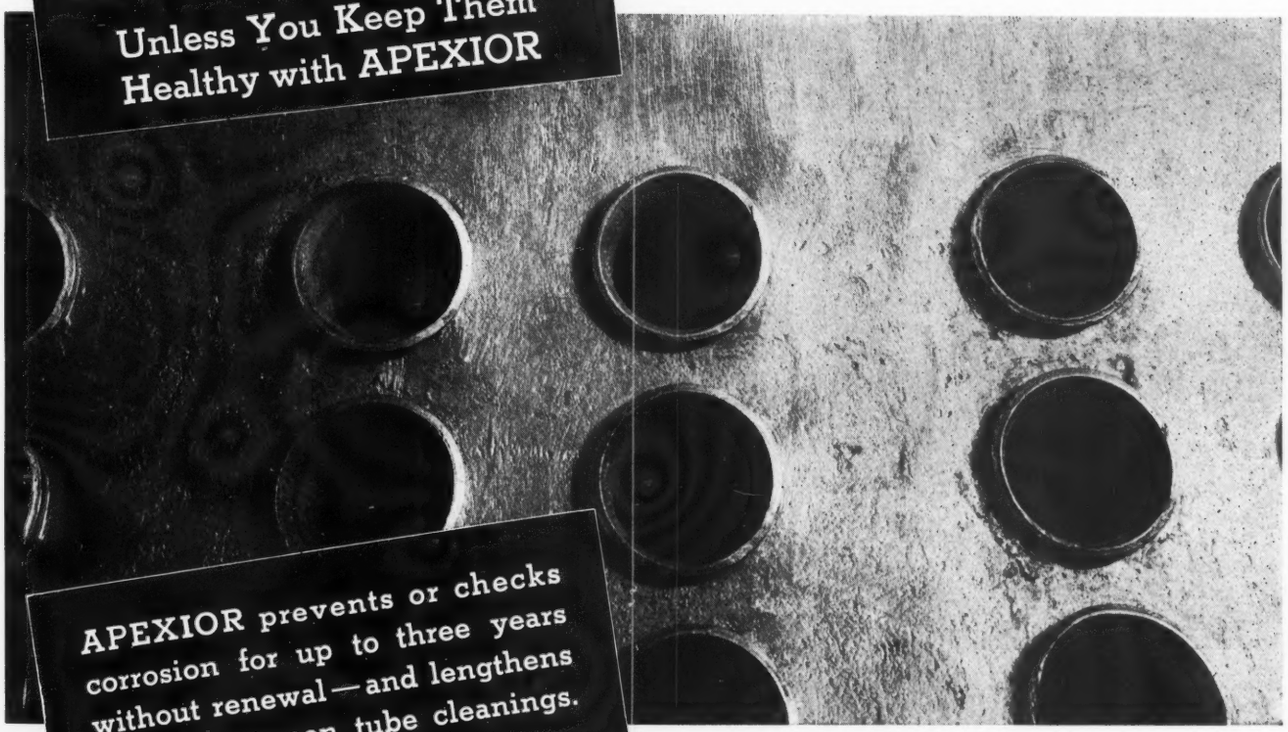
11 WATER-CONSERVATION EQUIPMENT—Water Cooling Corp, 71 Nassau St, New York, N. Y. Catalog describes company's line of mechanical draft cooling towers, atmospheric cooling towers, spray-nozzle cooling systems and roof cooling systems. Schematic diagrams and

In 12 Months... It May be 1944 to Your Boilers

Unless You Keep Them Healthy with APEXIOR

Boilers that in years past have spent much of their time *cooling off* are now being forced to make steam twice around the clock each day—and sometimes seven days a week!

The natural consequence of this—especially where feedwater supply is not the best or proper conditioning is difficult—is that such boilers are going to run into trouble long before their normal time . . . unless steps are taken to keep the trouble away!



APEXIOR prevents or checks corrosion for up to three years without renewal—and lengthens periods between tube cleanings.

APEXIOR coating, in applications experiencing corrosive waters, prevents corrosion in new boilers and checks it in old boilers. The approval and recommendation of all U. S. and Canadian boiler insurance companies provide a convincing measure of its efficiency. Many large companies—even with the best of water conditions—or the finest of water treatment—insist upon the added protection of APEXIOR.

In scaling waters, brush-applied APEXIOR prevents the tight bonding of water scale. You will need less often to take time out for cleaning—and when the infrequent cleaning is done, the scale is much easier to remove.

ANOTHER AID TO TIME-SAVING

is the new Tube Coating Machine which not only speeds up tube coating, but also improves the quality of the coverage.

Have us send you Bulletin 1290 which will show you how to establish a basis for better boiler maintenance—and freedom for years to come from the troubles and delays that you can't afford to have.

APEXIOR
REG U.S. PAT. OFF.

THE DAMPNEY COMPANY OF AMERICA

PROTECTIVE COATINGS FOR STATIONARY BOILERS, LOCOMOTIVES AND STEAMSHIPS

HYDE PARK · BOSTON · MASSACHUSETTS

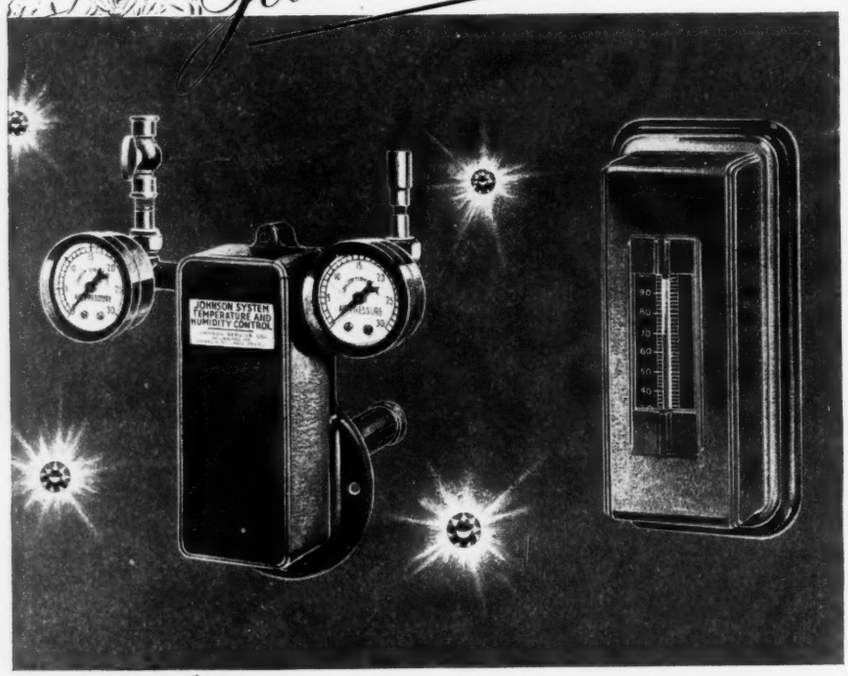
Atlanta Chicago New York Detroit Philadelphia

Engineering Sales Representatives — Pittsburgh, Cincinnati, New Orleans, San Francisco, Los Angeles, Portland, Seattle, Phoenix, Denver, Salt Lake City, Dallas, Houston, Vancouver, B. C., Montreal P. Q., Havana, Cuba, Manila, P. I., Honolulu, T. H., Marine Dept., 114 Liberty St., New York, N. Y.

G-R-A-D-U-A-L CONTROL!

JOHNSON'S SMOOTH-OPERATING

Jeweled Movement



FOR LONG-TIME PRECISION

Johnson uses *sapphire jewels* in the bearings of thermostats and humidostats! Accurate performance depends upon smooth, easy movement of the levers in such instruments. Friction must be held to a minimum. Consequently, Johnson's strict standards demand hardened steel pivots, operating against precious stones. This means less friction than any other combination of bearing materials. Such care may seem like needless refinement. But Johnson is not satisfied merely to produce thermostats and humidostats that are just good enough to "get by."

The recognized Johnson standard of excellence is "precision instruments for precise control" of comfort air conditioning and industrial processing. Here, again, is evidence of the extreme care and precision that characterizes the design and manufacture of Johnson's modern apparatus. Send for bulletins which describe the smooth-operating jewelled movement instruments and other interesting Johnson equipment.

JOHNSON CONTROL: *The "BRAIN" of the Air Conditioning System*

JOHNSON

Automatic TEMPERATURE AND AIR CONDITIONING ***Control***

JOHNSON SERVICE COMPANY, MILWAUKEE, WIS. & BRANCHES IN PRINCIPAL CITIES

Describes features of each machine individually and points out advantages of combination.

40 DISPERSION DRYER — Western Precipitation Corp, 1016 W Ninth St, Los Angeles, Calif. 8-page bulletin features Turbulaire dispersion dryer, used for drying slimes, pulps, colloids, etc, which cannot be filtered. Points out varying range of application for dryers.

41 FLOOR GRATING—Walter Bates Co, 208 S La Salle St, Chicago, Ill. 12-page catalog No. 937 describes and illustrates Bates floor grating, stair treads, floor armor and bridge decking. Numerous unretouched application photos included.

42 SERVICE CLAMPS—Band-it Co, 2536 Walnut St, Denver, Colo. 4-page folder describes numerous uses of Band-it clamp, for repairing all sizes and types of hose, pipe, tanks, etc. Photographs show how to apply clamp correctly.

43 GRATING—Wm F Klemp Co, 6601 S Melvina Ave, Chicago, Ill. 8-page folder No. 14-R describes Klemp floor products, including open steel flooring, grating, grating flooring, stair treads, heavy-duty industrial traffic surfaces, bridge, ramp and loading-platforms flooring, floor armor, decking and armor grids.

44 SAFETY TOOLS—Ampco Metal, Inc, 1745 South 38th St, Milwaukee, Wis. 8-page folder describes complete line of Ampco non-sparking safety tools, illustrating each.

45 INDUSTRIAL PRODUCTS—Johns-Manville, Inc, 22 E 40 St, New York, N. Y. 52-page illustrated catalog contains information and recommendations on high- and low-temperature insulations for every industrial need from 400 F below zero to 2500 F above. Data also included on refractories and castables, built-up roofs, electrical conduit, packing and gaskets.

46 CASTINGS — Meehanite Institute, 311 Ross St, Pittsburgh, Pa. 49-page booklet entitled "Meehanite in Industry" contains numerous articles about Meehanite castings, covering descriptions of applications in wide variety of industries.

47 STEEL MATS—Wm F Klemp Co, 6601 S Melvina Ave, Chicago, Ill. 4-page booklet presents advantages of Klemp safety steel mats in industrial plants. Mats can be cleaned, have non-skid grid, and can be rolled like a rug. Other Klemp products illustrated.

48 PILOT LIGHTS—Dial Light Co of America, 90 West St, New York, N. Y. 8-page bulletin lists, describes and illustrates many types of pilot-light assemblies including special enclosed lamps, and standard setups with removable parts.

49 SHAFT SEALS—Fulton Sylphon Co, Knoxville, Tenn. 16-page illustrated catalog covers Sylphon shaft seals, used to prevent leakage of a liquid or gas around a rotating shaft. Both stationary and rotating type seals are described and illustrated.

50 BUILDING MAINTENANCE — Flexrock Co, 2377-A Manning St, Philadelphia, Pa. 74-page handbook has technical information for plant managers, maintenance men and superintendents. Shows how to do many odd jobs at lower cost with better results, and presents numerous ideas that save time and money. Non-technically written.

51 LUBRICATION — Lubriplate Div, Fiske Bros Refining Co, Newark, N. J. 16-page illustrated bulletin No. 12-40 covers Lubriplate lubrication. Basic facts on Lubriplate presented, types of lubricant available, and applications of the lubricant. Numerous testimonial letters from purchasers exhibited.

52 FELTS—Feldters Co, Inc, 210 South St, Boston, Mass. Comprehensive handbook on felt seals for lubricants, contains handy specifications, information and details.

53 SPRAY PAINTING—Binks Mfg Co, 3114 Carroll Ave, Chicago, Ill. 92-page loose-leaf catalog gives complete engineering data and specifications, together with prices on spray booths, spray guns, oil and water extractors, air supply and exhaust systems, portable painting outfits and automatic finishing equipment.

54 PILOT LIGHTS—Signal Indicator Corp, 140 Cedar St, New York, N. Y. 4-page folder illustrates and describes all types of pilot light assemblies, giving sizes available, and prices of each.

CASH STANDARD *Streamlined* TYPE 1000 PRESSURE REDUCING VALVE

"NEVER TOUCH THEM"

"Our men say they specify your Streamlined 1000 Valves because they are accurate and because they never had to touch one of them since they were installed. I don't see how you could wish for a better report."—Case No. 358.

"Nobody had to look at it"

"I was sincere when I told you we had no Streamlined Valve here because I look after all the valves. But since you gave me the date and order number I looked into it and all I can say is—'you're right!' There is one here. But nobody has had to look at it since it was installed two years ago. I'm glad you came back at me because I'm strong for valves like that."—Case No. 360.

"ABSOLUTELY NO TROUBLE"

"How long will it regulate without attention? that's our test for any automatic valve. We put our first Streamlined Valve on a job that we thought no regulator could handle 100%. It was a spot where no regulator had lasted six months. Your Streamlined Valve has been handling this job for over three years with absolutely no trouble. Since that time we have bought 20 or 30 more, as you know, and they all give us the same fine performance."—Case No. 337.

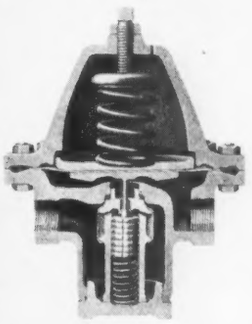
"NOT A SINGLE CASE OF TROUBLE"

"We've got a lot of your Streamlined Valves here and they must be working well because I haven't had a single case of trouble reported on them. When something works well we usually stick to it, so you'll be hearing from us right along."—Case No. 366.

A CASH STANDARD "GET ACQUAINTED" COLUMN

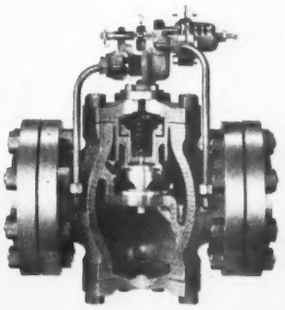
Question: "Don't you people make anything besides that Streamlined Valve you talk about so much?"

Answer: "Yes Sir; we do! And we propose to picture one or two of them here each time."



Cash Standard Class D Pressure Reducing Valve; inexpensive; dependable. Used in regulating steam, hot water, cold water, air, oils, many chemicals and most gases. Sizes ¼" to 2"; screwed ends.

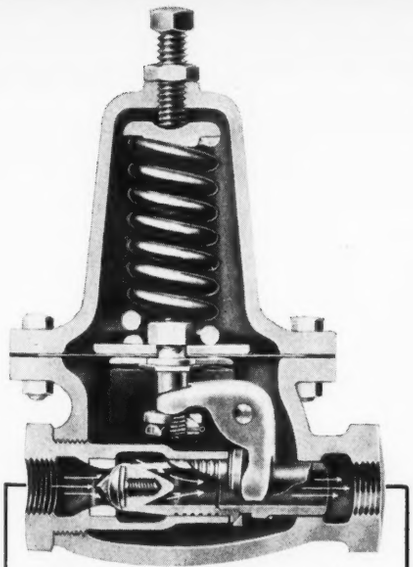
Initial pressures up to 250 lbs., reduced pressures up to 200 lbs. Bodies in iron, bronze or steel. Trim; iron, bronze, stainless steel, monel metal, or nitralloy.



Cash Standard Type 10 Pressure Regulating Valve—self-contained, pilot operated. For holding reduced pressure within extremely close limits.

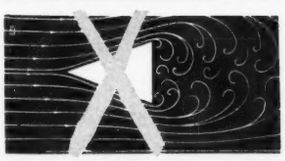
Sizes: 2" to 12". Initial pressures up to 600 lbs.; highest reduced pressure 250 lbs. For water, air, Freon, ammonia, any non-corrosive gas or oil. Valve operating fluid not wasted: it discharges to outlet pipe.

Bodies: iron, bronze, steel. Trims: iron, bronze, stainless steel, or monel metal. Ends: screwed, flanged, or ammonia type.

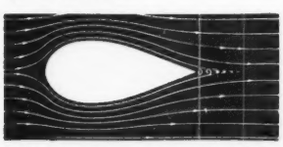


Straight Line Flow
FROM INLET TO OUTLET

Trouble-free service seems to be the general verdict — you can expect the very same results when you install a CASH STANDARD Streamlined "1000" valve — but the type "1000" doesn't stop there — plus this you get smooth operation — no flow variation — high capacity — tight closure when not in use—accurate regulation—and, in addition, your type "1000" will contribute towards speedier production and do it at lowest cost to you. Whenever the time should come that replacement is needed, you'll find it only necessary to order an inexpensive replacement part and you can easily install the part yourself.



NONE OF THIS TURBULENCE
In the Streamlined Valve there is no turbulence like that indicated in the diagram above to hinder flow or handicap close pressure regulation.



GIVES THIS FLOW PATTERN
The Streamlined form of the inner valve eliminates turbulence. It produces the flow pattern shown above which makes for maximum capacity when it is needed most, and permits accurate pressure control under toughest working conditions.

Try One Free
FOR 30 DAYS

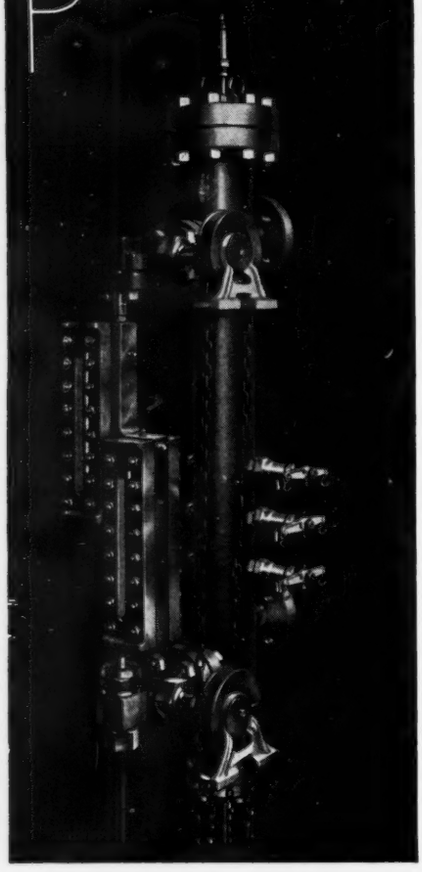
Prove to your own satisfaction just how good type "1000" is—take 30 days to do it—after 30 days a bill is sent to you—you either pay the bill or return the valve to us at our expense. Send for one now.

A. W. CASH COMPANY
DECATUR, ILLINOIS

CASH STANDARD CONTROLS . . VALVES

Get Free Bulletins on Above . . . Write to
A. W. CASH COMPANY
DECATUR, ILL.

POSITIVE
Protection



Yarway's unique Hi-Lo Alarm mechanism utilizes balanced *solid weights* that are as indestructible and unchanging as the metal itself. Operating on the displacement principle, they literally "weigh the water level."

When the high or low water emergency occurs—instant, positive, powerful, hair-trigger *action* results—giving warning of danger by whistle, light, or both.

Yarway Water Columns, eight standard models, iron bodies with screwed connections for pressures up to 250 lbs., forged steel bodies with flanged connections for pressures up to 1500 lbs., are fully described in Catalog WG-1807. Write for a copy and working model.

YARNALL-WARING COMPANY
100 Mermaid Ave. Philadelphia

YARWAY
FLOATLESS HI-LO ALARM
WATER COLUMN

Current Comment

(*Continued from page* 124)

tattered dungaree pocket and pulled out a round object that gleamed in the light. It was the eyebolt!

The chief looked at the third, the third at the second who was in the act of slapping a big mosquito off his blackened arm, and turned towards the ladder. Now, that old scow had a fairly sober black gang. However, that night when the last line was cast off, I must admit that there were few of us who could walk a straight line and even fewer of us who wanted to.

New York, N. Y. TYLER G HICKS

Gear Teeth Don't Roll

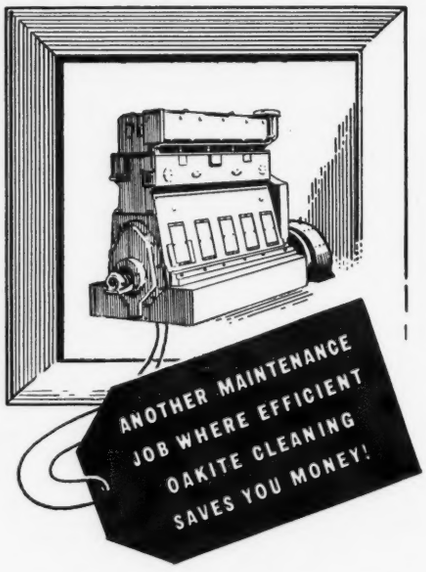
THE SPECIAL SECTION "Mechanical Power Transmission," February POWER, is very interesting and helpful, but I don't know if the author intends to imply in the first sentence of the second paragraph under "Gear Drives", that gear teeth, if properly formed, have pure rolling motion only. Also, in order to achieve this action, does he imply that curves such as the cycloid and involute are used?

I find that this is a very common conception, even in students who are taking or have taken a course in kinematics. As a matter of fact, gear teeth have a relative sliding motion at all points of contact except right at the pitch point where the relative motion is pure rolling. The rate of slip between the teeth is easily shown to be proportional to the distance the point of contact is from the pitch point. This sliding action is in a radial direction for spur gear teeth and for helical teeth there is a combination of radial and axial sliding action.

I think the reason why involutes and cycloid curves are used is because they are exact mathematical curves that can be reproduced by anyone anywhere and thus obtain interchangeability, and being mathematical curves, they lend themselves to exact analyses. As a matter of fact, one can choose any arbitrary curve for the outline of the teeth on one gear and then construct a mating curve for the profile of the teeth on the other gear. The result is a pair of gears that will fulfill the basic law of gears, which is that the normal at the point of contact shall cut the line of centers at a fixed point. This is all that must be achieved in order to have a constant gear ratio.

Blacksburg, Va. JAMES I CLOWER
Virginia Polytechnic Institute

Is YOUR Diesel Engine Running TOO HOT?



When your Diesel overheats the thing to do is to remove those scale and rust deposits causing the trouble. But do it easily the successful, SAFE, low-cost Oakite way!

Just circulate Oakite Compound No. 32 solution through scale-clogged passages . . . or let "soak" for short time as directed. Results will please you. For this specially designed material removes insulating deposits to restore cooling efficiency and increase power output. Many power plant engineers say this de-scaling method is the easiest, most effective and economical they have ever used!

WRITE FOR BOOKLET

This 20-page booklet gives concise, money-saving data on this and such other jobs as cleaning and de-scaling Diesel jacket-water coolers, surface condensers, heat exchangers, "lube" oil coolers, water-cooled compressors. Write today for your FREE copy!

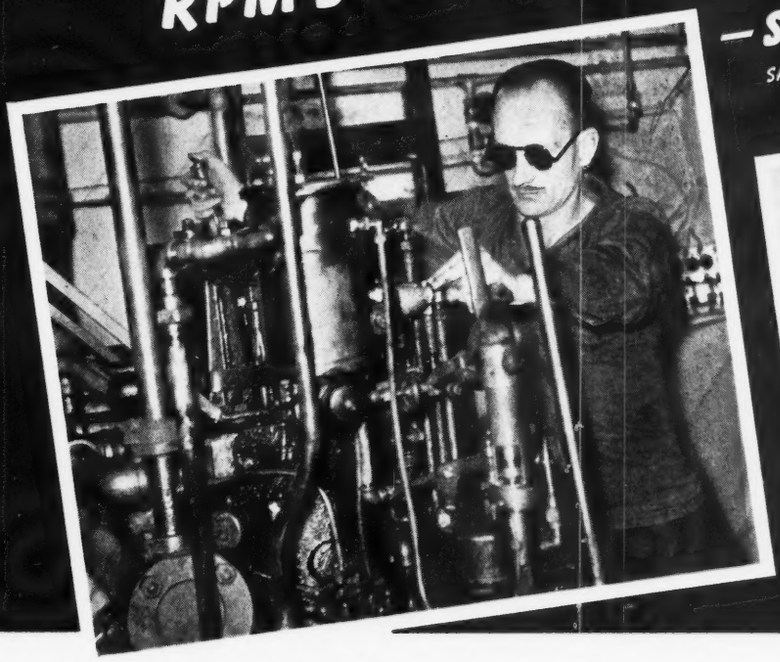
OAKITE PRODUCTS, INC.
23 Thames Street, New York, N. Y.
Representatives in All Principal Cities of the United States and Canada.

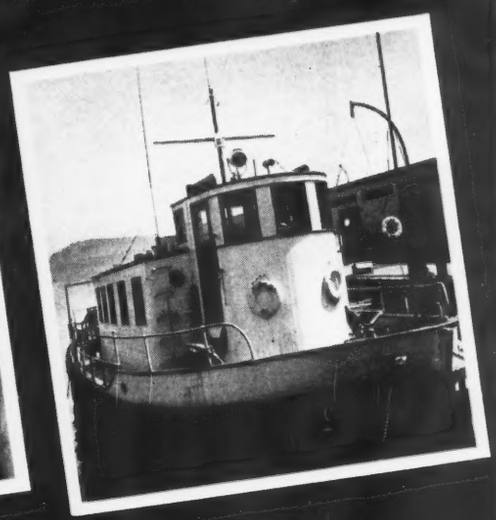
OAKITE
Certified cleaning
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

BELIEVE IT OR NOT!*— "RING-FREE REMOVED CARBON, FREED THE RINGS; GAVE MORE RPM'S IN THIS ATLAS DIESEL"

—SAYS BOB GRIMES,

SAN FRANCISCO SPORT-FISHING BOAT OPERATOR.



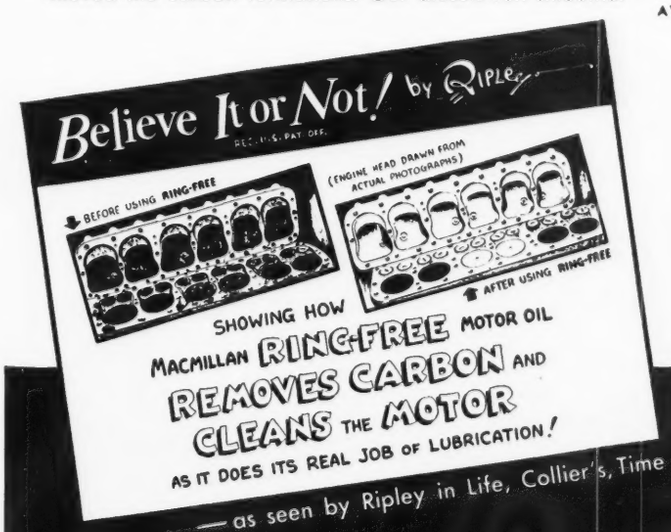


To deep-sea fishing enthusiasts of San Francisco Bay, Bob Grimes' sport-fishing boats are known as "lucky" boats. Bob, who does most of the maintenance work himself on the Atlas-Imperial engines, says it was another "lucky" day... for the boats... when he first tried Ring-Free. "It reduced our lube oil consumption; freed the rings... removed the carbon formations. Our diesels run smoother and give more rpm's with the same load."

Why not see for yourself how Ring-Free gives you cleaner motors, fewer overhauls and more power? Call the Macmillan Man for proof... or write us direct.

MACMILLAN PETROLEUM CORPORATION

50 WEST 50TH STREET, NEW YORK • 624 SOUTH MICHIGAN AVENUE, CHICAGO • 530 WEST 6TH STREET, LOS ANGELES


Believe It or Not! by Ripley
REG. U.S. PAT. OFF.
BEFORE USING RING-FREE
(ENGINE HEAD DRAWN FROM ACTUAL PHOTOGRAPHS)
AFTER USING RING-FREE
SHOWING HOW
MACMILLAN RING-FREE MOTOR OIL
REMOVES CARBON AND
CLEANS THE MOTOR
AS IT DOES ITS REAL JOB OF LUBRICATION!
— as seen by Ripley in Life, Collier's, Time

MACMILLAN RING-FREE MOTOR OIL

*Reg. U.S. Pat. Off.

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MAXIM
SILENCERS

FOR EVERY INDUSTRIAL SILENCING PROBLEM

With Maxims you don't just buy a silencer—you buy *the* silencer specifically built for your particular type of installation.

This of course can only be true where you find a complete line of silencing equipment such as that offered by Maxim.

Maxims are built for the exhaust or intake of internal combustion engines, for high or low pressure steam discharge, and for compressor intakes, blowers, etc. . . . and there are several MAXIM models built for each use.

SEND THIS COUPON FOR DETAILS

THE MAXIM SILENCER COMPANY
92 Homestead Ave., Hartford, Conn.

Please send details on your ☐ Engine exhaust ☐ Steam ☐ Compressor Silencers.

Name .....

Company .....

Address .....

City ..... State .....

Mercury-Steam Plant

(Continued from page 67)

bination of magnesium and titanium has been found to hold the boiler tubes in a properly wetted condition unless the air infiltration is excessive. It appears that magnesium, about 0.002%, is essential to maintain the titanium active, and that the latter metal aids in wetting the steel.

The formation of oxides formerly caused considerable trouble, dewetting and deposits in tubes, sumps and pipes. Air infiltration is now counteracted by the magnesium and titanium treatment, but excessive amounts mean loss of these metals. A new type shaft packing and coverings for valve stems operating under vacuum have reduced air leakage at Kearny from 300 cu ft per hr to less than 0.4 cu ft. This slight amount, only partly oxygen, combines with magnesium to form magnesium oxide which is easily cleaned out.

Tests during May and June, 1940, show a full-load net-plant heat rate of 9175 Btu per kwhr, Fig. 4, including auxiliary power consumption and allowing calculated amounts for production of electrical output by steam turbines. This corresponds to a thermal efficiency for the cycle of 37.19% and means that a kwhr is being produced for 0.502 lb of 18,275-Btu-per-lb bunker oil.

Power Lines

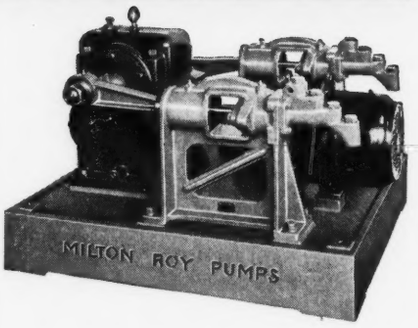
H L Solberg New Head of Purdue ME Dept

Harry Leland Solberg, professor of Mechanical Engineering at Purdue University, has been appointed head of that department.

Born in South Dakota in 1898, Professor Solberg was graduated from South Dakota College in 1920, received two degrees from that institution and was advanced to full professorship of mechanical engineering in 1936. While at South Dakota he worked on the design of the mechanical engineering laboratory and the university heating and power plant.

At Purdue Professor Solberg has been in charge of high-pressure, high-temperature steam research. ASME papers, presented in collaboration with Dean Potter and Dr Hawkins, include:

MILTON Roy PUMPS
Chemical Feeders and Proportioners



No Matter How High The Boiler Pressure!

Milton Roy Duplex Pumps will handle boiler-treating solutions against *any pressure that may be encountered*, right up to the critical 3226 lbs. at 706.1° F.

Step-type valve bodies are of steel. Valve-seats, ball-checks and pistons are stainless. The stroke of each pump unit is adjustable to deliver from zero to 100% capacity.

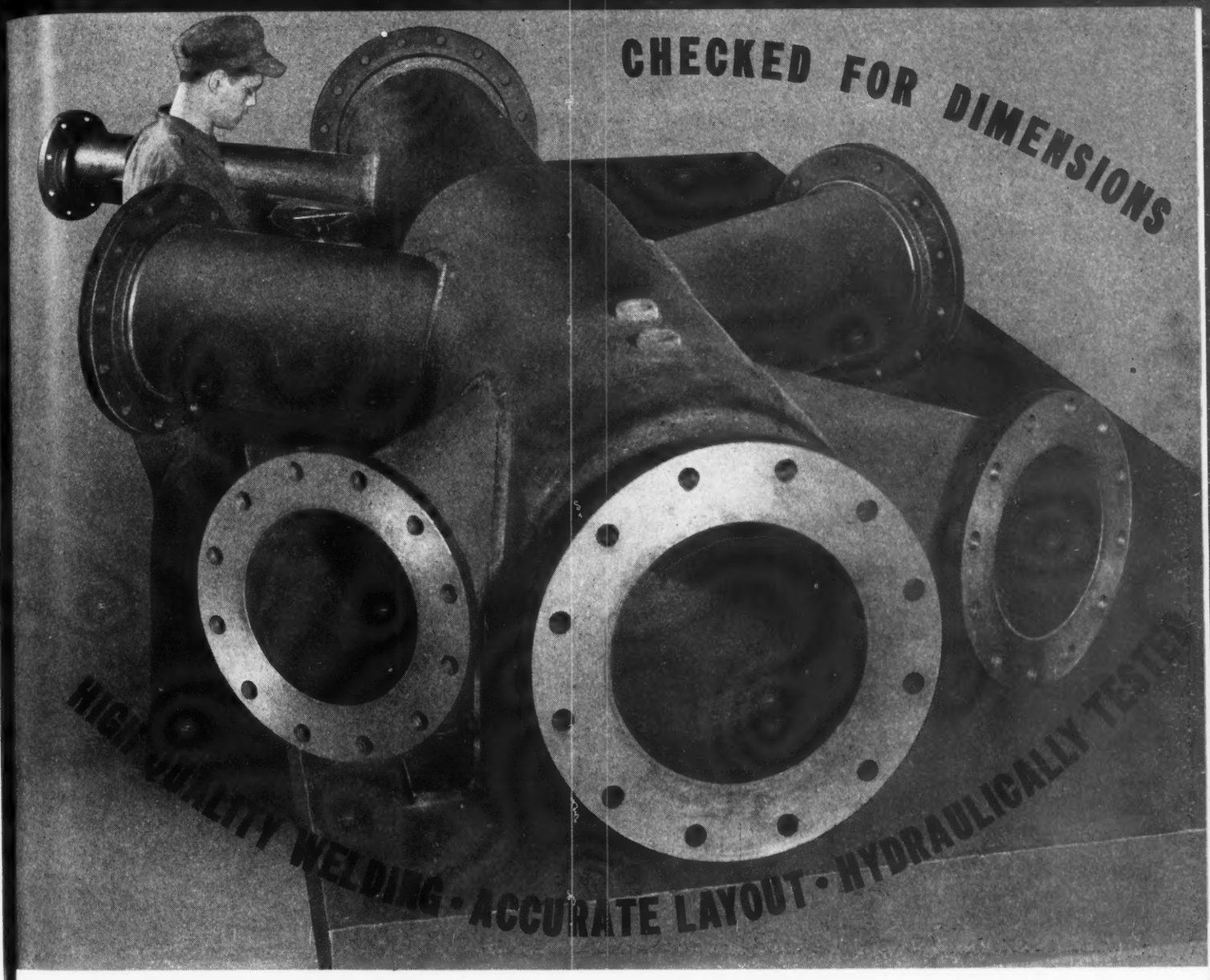
These pumps are built to handle such chemicals as

- Sodium Sulfite
- Sodium Phosphates
- Calgon • Soda Ash
- Caustic Soda • Lime
- Organic Boiler Treatments

Exclusive step-valve construction, high volumetric efficiency, exact control of capacity, low power requirements, readily accessible double-ball checks, simplicity, ruggedness . . . many features recommend Milton Roy Pumps.

Have you copies of our Proportional Feed Diagrams? Six now available. Of real value if you have problems of accurately proportioning or measuring. Free for the asking.

MILTON ROY PUMPS
1362 E. Mermaid Ave., Chestnut Hill, Phila., Pa.



Prefabricated BY EXPERTS UNDER CONTROLLED CONDITIONS

MODERN piping systems place more and more emphasis on accurate piping fabrication that can comply with stringent specifications. At Pittsburgh Piping such accuracy begins in the engineering department where fabrication details are carefully planned and the layout is detailed for the most efficient method of shop fabrication.

Special jigs and positioning equipment permit the welders to work in a natural position. Modern facilities for machining, straightening and checking for dimensions insure fabrication to close tolerances. By pre-fabricating complex assemblies as large as shipping facilities and installation space will permit, insurance inspection (where required) and final erection are greatly simplified.

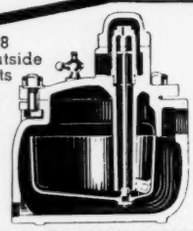
With time the vital element, faster and better pre-fabrication by Pittsburgh Piping experts is of decided advantage.

PITTSBURGH PIPING & EQUIPMENT CO.
10 FORTY-THIRD STREET PITTSBURGH, PA.

Woolworth Bldg., New York · Occidental Bldg., Indianapolis · Peoples Gas Bldg., Chicago · Union Guardian Bldg., Detroit
Public Sq. Bldg., Cleveland · 10 High St., Boston · Liberty Life Bldg., Charlotte · 525 Market St., San Francisco

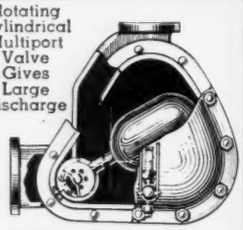
Pittsburgh Piping

COCHRANE
Drainage Equipment for a wide range of Operating Conditions...

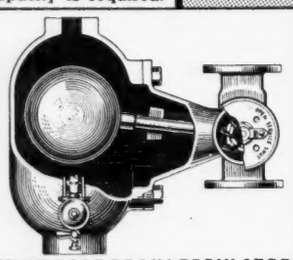


HEAVY DUTY BUCKET TRAP

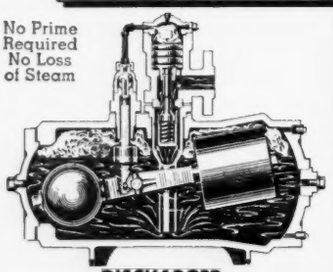
Large cast-iron bucket holds valve tightly to seat until water overflows rim, opening valve wide.



MULTIPORT DRAINER
For handling drainage of low-pressure separators or other apparatus where large discharge capacity is required.



MULTIPORT DRAIN REGULATOR
Continuous discharge is maintained by height of condensate in body. Valve shuts off discharge when condensate falls to normal level. Tremendous discharge capacity.



DISCHARGER
For removing large quantities of condensate under high pressure (150 to 2000 lb./sq. in. or higher) from heaters, purifiers, coils, etc.

COCHRANE CORPORATION
3106 N. 17th Street, Philadelphia, Pa.

COCHRANE

Cochrane Corp., 3106 N. 17th St., Phila., Pa.
Please send me copies of your Publications on Condensate Drainage.
Name.....
Firm.....
Address.....
City..... State.....

"Characteristics of High-Pressure Steam Generators," "Flow Distribution in High-Pressure Steam Generators," "The Viscosity of Superheated Steam," and "Corrosion of Steel by High-Temperature Steam." Professor Solberg is the author of numerous articles on fuels, combustion, high-pressure steam, piping, and power-plant economics, which have appeared in POWER and other technical magazines.

Guffey Coal Act Extension Favored

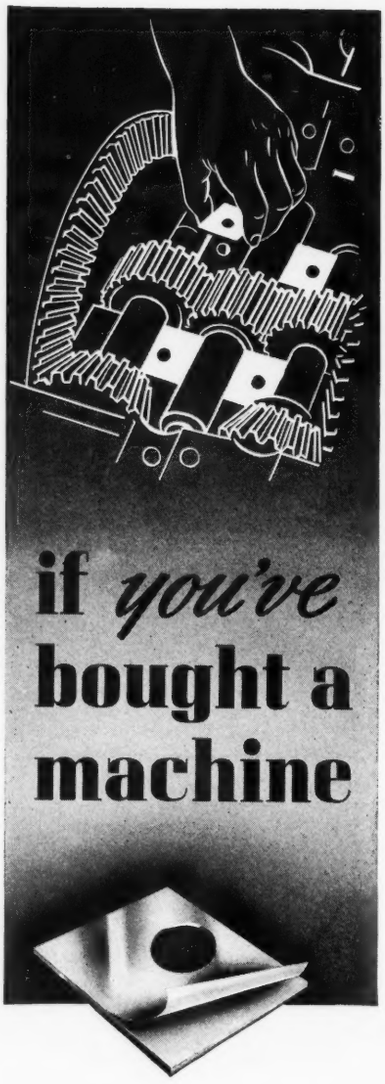
A 2-year extension of the Guffey-Vinson minimum-price law has been recommended, and, according to the returns of a poll of bituminous producers conducted by *Coal Age*, the suggestion was favored nearly 3 to 1. Unless action is taken by Congress, the Guffey-Vinson minimum-price control law will expire April 26, by statutory limitation.

Every major soft-coal-producing region but one, the Southwest, gave the suggestion a substantial majority. The weighted average for all producing fields combined showed that 73.8% of the operators expressing an opinion voted for the extension.

With few exceptions, according to *Coal Age*, these same operators reported that their average price realizations during the first three months the minimum prices were in effect had increased over the figures for the last quarter of 1939.

William W Crawford of Edward Valve Dies

William W Crawford, widely known among power men as president of the Edward Valve & Mfg Co, Inc, East Chicago, Ind., died at Miami Beach, Fla.,



—or intend to...

Probably Laminum shims are standard equipment on your new purchase. If not, when you service it use Laminum for quick adjustments of bearings and fitted mechanical parts. It pays! Simply *peel* off .002 or .003 inch brass laminations. For *precision* adjustment! • *Shims cut to your specifications . . . stock shim materials are sold by mill supply distributors.*

Laminated Shim Co., Inc.
61 Union St., Glenbrook, Conn.

Write for file-folder of shim application photos—with Laminum sample.

LAMINUM
REG. U.S. PAT. OFF.
THE SOLID SHIM THAT *peels* FOR ADJUSTMENT
A-1170

THIS IRON FIREMAN PAID FOR ITSELF IN 1 YEAR

Virginia Furniture Plant Proves Pneumatic Spreader Superiority

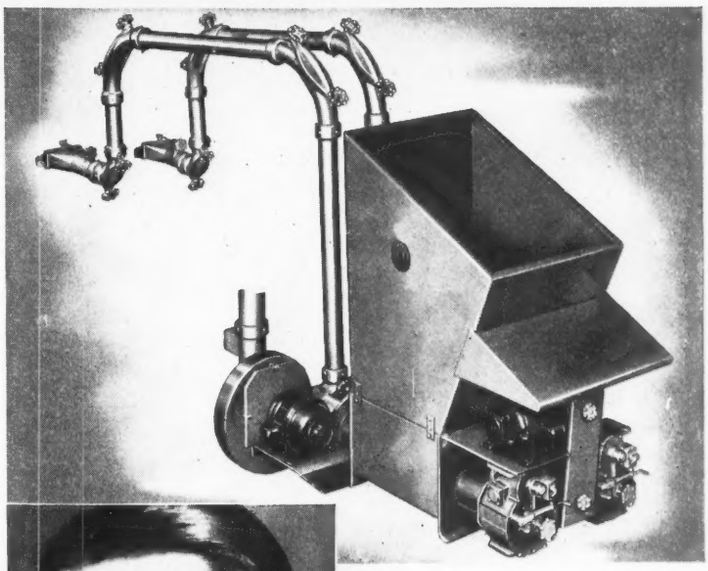
In less than one year's operation of an Iron Fireman Pneumatic Spreader in the Virginia-Lincoln Furniture Corp., Marion, Va., *the complete investment was written off in savings!*

Virginia-Lincoln, like many wood-working plants, burns fuel varying from all coal to all wood. The Iron Fireman Pneumatic Spreader firing two boilers facilitates control of coal supply to meet the varying supply of wood refuse. It cuts down fuel waste; reduces labor.

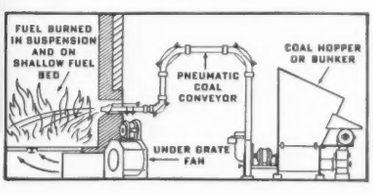
Reports J. D. Lincoln, vice-president: "We consider the purchase a good one in every respect and gladly recommend the equipment to others."

Learn what YOU can save

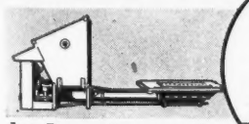
We are ready to make an Iron Fireman Engineering Survey of your steam requirements—cooperating with your engineer or consulting engineer. The Survey will be similar to the one that accurately foretold Virginia-Lincoln's savings. There is no obligation. Mail coupon below.



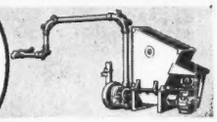
Above: Iron Fireman Pneumatic Spreader with dual conveying systems; the type firing boilers in the Virginia-Lincoln Furniture Corp. *Left:* J. D. Lincoln, vice president of the Virginia-Lincoln Furniture Corp., Marion, Va. *Below:* Firing diagram of typical Iron Fireman Pneumatic Spreader installation.



IRON FIREMAN Automatic Coal Stokers



Iron Fireman Poweram stoker combines worm feed and ram distribution of coal in retort.



Iron Fireman Pneumatic Spreader stoker fires coal on a stream of air.

IRON FIREMAN MANUFACTURING CO., [Portland, Ore.; Cleveland; Toronto.]
Mail to 3010 West 106th St., Cleveland, Ohio.

☐ See us about making an Iron Fireman Engineering Survey of our steam costs.

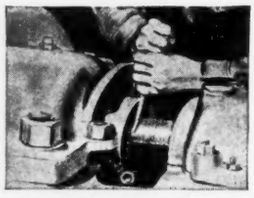
Send: ☐ Poweram Catalog. ☐ Pneumatic Spreader Catalog.

*Name*_____

*Address*_____

If you think all Packings are alike . . .

Test PALMETTO* and note the difference



Yes, we agree that all packings *look* more or less alike from the outside. So how can you tell a superior packing from an ordinary one? The best way is by actual test—that's the way many other engineers have proved to their own satisfaction that PALMETTO *is* superior.

FREE Working Sample

Don't take our word for it. Test a working sample under your own operating conditions, without charge or obligation. More than 90% of the engineers who have made this test have become permanent users. To find out why, send us the coupon on a postal card, stating the size and service, and free working sample will be sent you.

GREENE, TWEED & CO.
101 Park Ave. New York

***PALMETTO PACKING**
for steam and hot fluids

Send the coupon

Reg. U.S. Pat. Off.

Greene, Tweed & Co., 101 Park Ave., New York
Send free working sample of packing.....size,
for ..... service.
Name .....
Company .....
Address .....

Feb. 19. He had been president of the company since 1923. Mr Crawford was born in Washington, Conn., in 1882 and attended Beloit and Oberlin Colleges. He started his business career as a newspaper man in El Paso, Texas, in 1905, and the following year joined the staff of the Chicago Record Herald.

At the time of his death, Mr Crawford was a member of the American Society of Mechanical Engineers, Western Society of Engineers, American Society for Testing Materials, American Society for Metals, American Chemical Society, Society of Automotive Engineers, American Society of Naval Engineers, and Chemical Industry, a British group.

OBITUARIES

CHARLES A STONE, 74, chairman of the board and co-founder of Stone & Webster, Inc, New York, died February 25, at his home following a siege of pneumonia. He was born in Newton, Mass., and attended Newton High School and Massachusetts Institute of Technology as a member of the institute's first course in electrical engineering. After graduation, Mr Stone served in the research labs of the Thompson Electrical Welding Co, and a year later became director of the New England Agency of the C & C Motor Co. Soon afterwards, he formed, with Edwin S Webster, a former classmate at MIT, his partnership, under the name, Massachusetts Electrical Engineering Co, Stone & Webster, managers. In 1890 the firm obtained its first engineering and construction contract, the Saccarappa, Me., hydroelectric installation and transmission line. Other contracts followed, among them one to construct ships for the government during the last World War. During these years Mr Stone, with the aid of his partner, built Stone & Webster to the largest engineering organization in the U. S. Among the firm's engineering and construction jobs were the Southern California Edison's Big Creek hydro station and steam station at Long Beach, Calif.; Mississippi River Power's plant at Keokuk, Iowa; Niagara Hudson station at Oswego, N. Y., and hydro plant and dam on the Susquehanna River at Conowingo, Pa. The firm also constructed buildings for MIT, University of Pittsburgh, the 50-story General Electric Building at 570 Lexington Ave, N. Y., and industrial plants for Johns-Manville, Anheuser-Busch, Westinghouse and other firms.

J J GREENE, vice-president, Johns-Manville Sales Corp, died February 27,

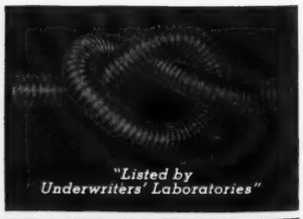
Babbitt
Adjustable
SPROCKET RIM
with Chain Guide
MAKE YOUR
OVERHEAD VALVES SAFE
and EASY TO REACH —
CONTROL VALVES
FROM THE FLOOR
With Babbitt Sprocket Rims on your overhead valves you can control valves instantly from the floor. Far quicker and safer than climbing ladders.
Babbitt Rims are easily attached in a few minutes, are inexpensive and assure safe, positive and instantaneous overhead valve operation. Available for valves of every make or style. Write for details.
BABBITT STEAM SPECIALTY CO.
New Bedford Mass.

ECLIPSE
SEAMLESS FLEXIBLE METAL HOSE

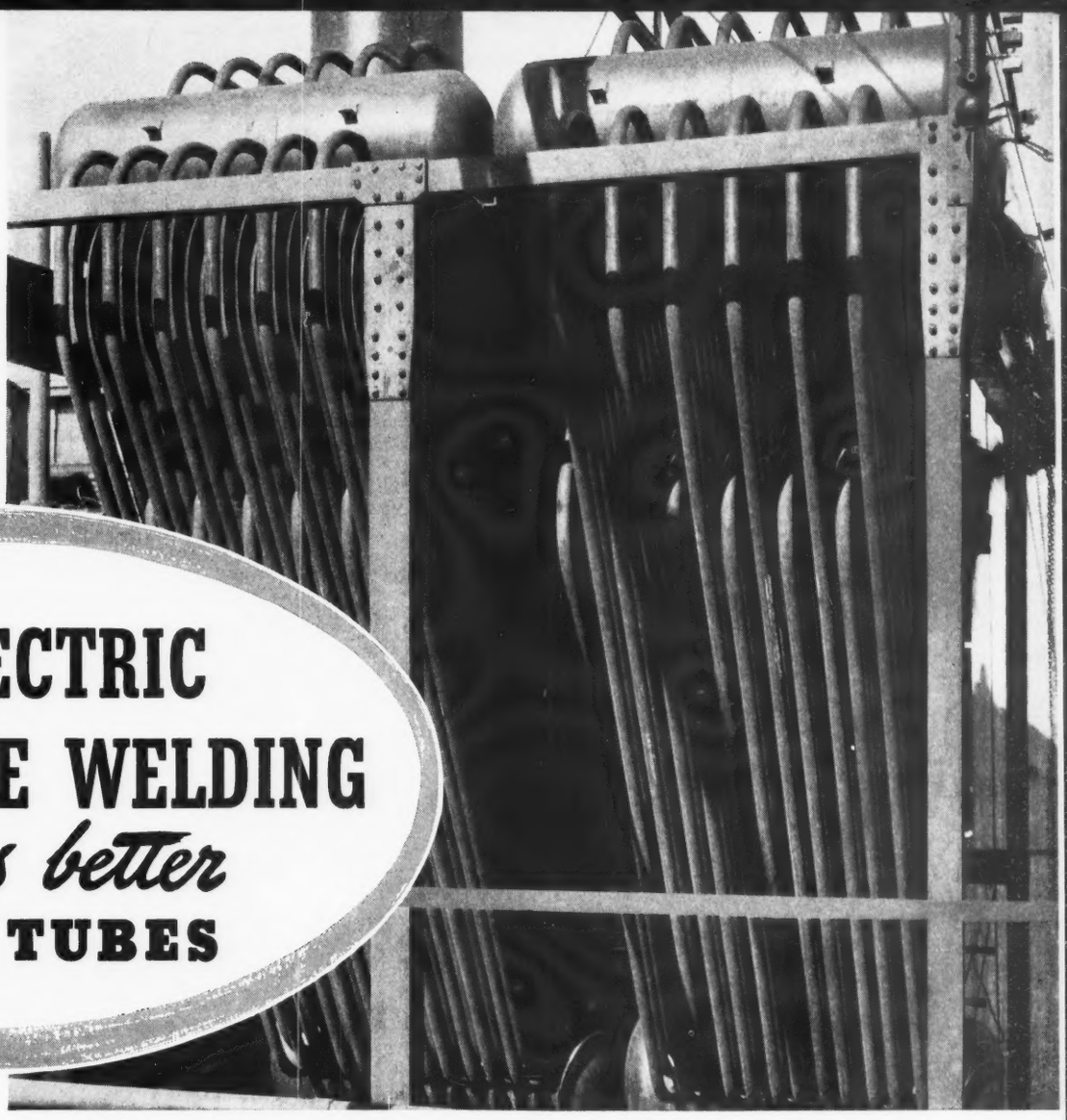
Normal Pitch

Of seamless, all metal, parallel corrugated, armored construction, in various alloys with renewable type fittings approved for the conveyance of non-solids and non-abrasives in *Aviation, Automotive, Marine, Heating, Air Conditioning, Mining, Power Generation, Plastic and Textile applications* wherein conditions of flexing and expansion between delivering and receiving connections exist. Also available for shielding and exhaust applications.

Close Pitch



METAL HOSE DEPARTMENT
ECLIPSE AVIATION, BENDIX, N. J.
DIVISION OF BENDIX AVIATION CORPORATION



Why ELECTRIC RESISTANCE WELDING *produces better* BOILER TUBES

● Yes — in many respects — Republic ELECTRUNITE Boiler Tubes are better tubes — because of the way in which they are made.

Why? First, the form used is flat-rolled strip steel. Both sides are clean, free from scale and carefully inspected. Thus, both inside and outside surfaces of the tubes are free from scale, scabs, slivers and other defects.

Second, because the strip steel is exact in width, and because it is cold formed to round shape by highly polished rolls, then electric resistance welded, the tubes are consistently uniform in size, diameter, concentricity and strength. *And the weld is as strong as the wall.*

Third, because the strip steel is rolled to accurate gauge, wall thickness of the tubes is uniform at every point. And, fourth, because the tubes are controlled-atmosphere annealed, they are uniformly high in ductility and retain the dense, glass-like surface produced by cold forming.

To you, these features — plus a series of rigid tests — become these advantages: (1) Accurate fit of tube in sheet hole. (2) Easy expanding, rolling and beading. (3) Tight joints. (4) Low installation costs. (5) A high factor of safety. (6) Long service life. (7) Low maintenance costs.

If you buy, build or operate boilers, it will pay you to investigate Republic ELECTRUNITE Boiler Tubes. Write Steel and Tubes Division, Republic Steel Corporation, Cleveland, Ohio.

REPUBLIC STEEL — DEFENSE FOR AMERICA

REPUBLIC

REG. U. S. PAT. OFF.

ELECTRUNITE

ELECTRIC RESISTANCE WELDED BOILER, CONDENSER AND HEAT EXCHANGER TUBES

HAVE YOU TRAP TROUBLES?

then cure them with the CRYER STEAM TRAP

Here's the answer to unreliable trap performance and high maintenance costs. Install CRYERS on those air-binding, slow-venting lines and your troubles will be over. They'll save enough in steam and in more efficient steam distribution to quickly return their moderate first cost.

FEATURES THAT MEAN SAVINGS

Look at some of the time and maintenance money saving features in CRYER STEAM TRAPS.

- . . . *all mechanism is removable without disturbing piping*
- . . . *all wearing parts are of stainless steel*
- . . . *venting is quick, positive and assures dependable drainage*
- . . . *installation is simple and easy*

These and many other advantageous features recommend CRYER INVERTED BUCKET STEAM TRAPS for your close investigation and early trial.

We carry all sizes of traps, and repair parts, of the line formerly known as the J-M Ball Steam Trap.

Sizes from ½" to 2½". Capacities from 500 to 38,000 pounds of water at pressures from 0 to 250 pounds.

GET ALL FACTS NOW!

CRYER TRAP & VALVE CO., INC.
Manufacturers of Steam Specialties for more than 40 years.
366 Madison Ave., New York, N. Y.

MASED LUBRICANT No. 177

for Bearing LUBRICATION in the HOTTEST Service Spots!

Economical, dependable maintenance of ball and roller bearing efficiency is assured at operating temperatures up to 500° Fahr.

Of a buttery consistency at room temperature, MASED LUBRICANT No. 177 defies the usual liquifying action of heat. *Give it a HOT SPOT test!* Center a piece of pea size on an electric hot plate! MASED *remains* buttery while other greases melt and run away.

MASED LUBRICANT No. 177 has a definite place in the lubrication of textile drying machinery, kiln and oven cars and innumerable types of equipment subjected to high temperature conditions.

● *Get more facts about this unusual Lubricant.*

BORNE SCRYMSER COMPANY
ESTABLISHED 1874
17 BATTERY PLACE · NEW YORK

at Avon Park, Fla., where he was on vacation. Born in London, England, in 1878, Mr Greene came to Canada at an early age, and later entered the United States. He was educated in Mechanical Engineering in Toronto, Canada. Before joining the Johns-Manville organization in 1906, he was connected with the engineering firm of McMann & Taylor.

DOUGLAS J MACLEAN, president and managing director of MacLean Underfeed Stoker Co, Ltd, West Hill, Ontario, Canada, died on January 31, 1941.

JOSEPH J BLACKMORE, charter member of the American Society of Heating and Ventilating Engineers, and its secretary in 1914 and 1915, died on February 11, after a brief illness. He was born in Yorkshire, England, in 1856 and came to Toronto, Canada, as a boy. He was a pioneer in the heating industry and for many years was associated with the J L Mott Iron Works. Mr Blackmore also shared in the formation of the United States Radiator Corp, Detroit, Mich., in 1910, when he served as secretary until his retirement in 1915. He was one of the few remaining charter members of the Society, having joined in 1895. For the past ten years he was a life member in the group.

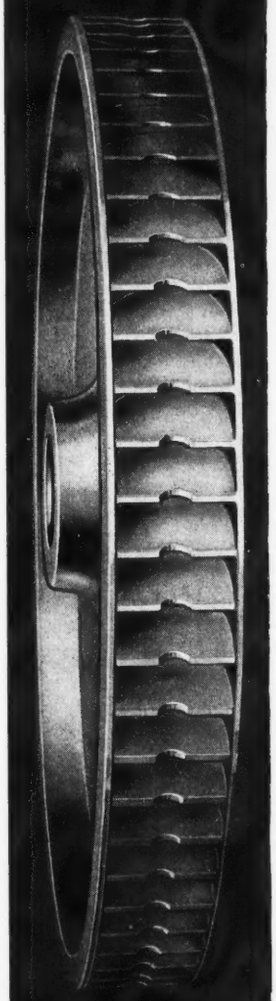
ALBERT W MOULDER, 52, vice-president of the General Fire Extinguisher and Grinnell Co's, Providence, R. I., and a leading authority on piping and heating problems in the engineering field, died in that city on Feb. 11.

FRANCIS JEHL, personal assistant of Thomas A Edison, and said to be the last of the Edison pioneers, died at Jacksonville, Fla., at the age of 80. For a number of years he had been curator of the old Edison Menlo Park Laboratories, restored at Greenfield Village, near Dearborn, Mich.

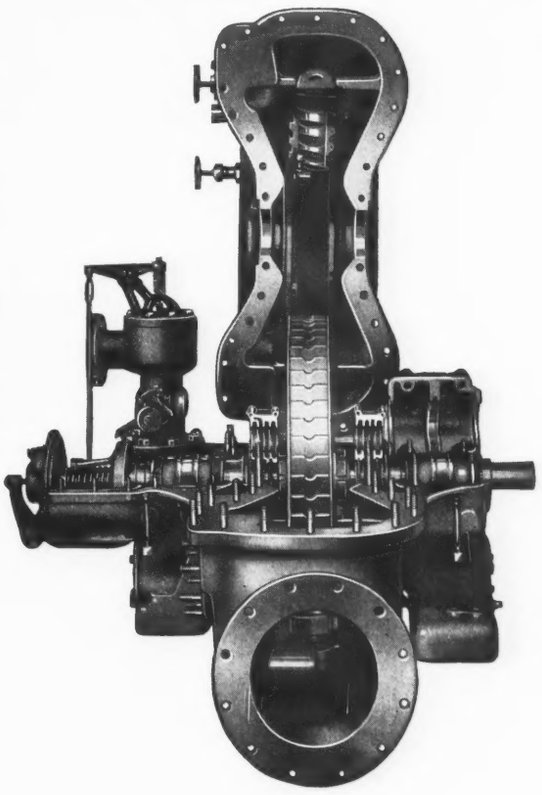
C R MESSINGER, president of the Chain Belt Co, died suddenly February 4, following a heart attack. He had been continuously identified with Milwaukee and Chicago business interests for many years. In addition to his being president of the Chain Belt Co, Mr Messinger was chairman of the boards of Oliver Farm Equipment Co, Sivyer Steel Casting Co, and director in several other companies, and assistant chief of the Chicago Ordnance District.

GUERNSEY A PALMER, 55, district manager for Baldwin De La Vergne Sales Corp and Baldwin Southwark Div of the Baldwin Locomotive Works in Houston, Texas, died suddenly at his

TERRY



SOLID WHEEL TURBINES are DOUBLE-RIM PROTECTED



In Terry Wheel Turbines the blades are protected by rims at the sides of the wheel, which would take without damage any rubbing that might occur if the clearance became reduced.

With this construction it is impossible for the blades to foul and frequent inspections of the thrust bearing are not required to obtain safe and dependable operation.

This and many other features of Terry wheel turbine design are fully described in our bulletin S-116. A request on your business letterhead will bring a copy.

Above:
Typical Terry Wheel Turbine with cover raised. Unit is rated 400 HP at 3500 RPM with steam conditions of 650 lbs. — 825 TT — 2 lbs.

T-1140

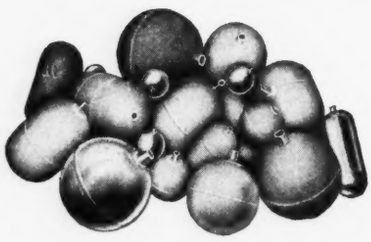
THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

NICHOLSON

HIGH PRESSURE WELDED FLOATS—Stainless Steel-Chromium Plated Steel

Available for all applications—for steam pressures up to 1500 lbs. and hydrostatic pressures up to 2500 lbs.—for corrosive and non-corrosive service.

Made in spherical and elliptical shapes in sizes from 2½" to 14" diameter. High in tensile strength and offer great resistance to external pressure. Special sizes and shapes available to order, and also cadmium, nickel or copper plated. Fully described in Bulletin No. 339.



2-, 3- or 4-WAY CONTROL VALVES for SINGLE and DOUBLE ACTING CYLINDERS

Special types also available.

Designed for long life, quick and dependable control of air, steam, oil, gas or water on pressures up to 300 lbs.

Made also in foot, solenoid and motoroperated types—also balanced valves for high pressure hydraulic service. Ask for Bulletin No. 933 for details.

OTHER PRODUCTS

NICHOLSON Industrial Steam Traps, Piston and Weight Operated Traps, Flexible Couplings, Expanding Mandrels, Arbor Presses, Compression Shaft Couplings, Steam Eliminators and Separators, Compressed Air Traps.

W. H. NICHOLSON & COMPANY
125 OREGON ST. WILKES-BARRE, PENNSYLVANIA, U. S. A.

COTTRELL PROCESS OF ELECTRICAL PRECIPITATION

universally recognized as a standard method of removing

DUST, FLY ASH, FUME, MIST & FOG *from* GASES

•

28 years of research development and operating experience by the affiliated Cottrell Companies throughout the world is incorporated in the

COTTRELL INSTALLATIONS

offered to meet the requirements of any problem by

RESEARCH CORPORATION

405 LEXINGTON AVENUE
NEW YORK CITY

59 EAST VAN BUREN STREET
CHICAGO, ILL.

home there on Feb. 8. A graduate of Massachusetts Institute of Technology, Mr Palmer received his M E Degree in 1915. He had been continuously associated with De La Vergne since March 1, 1916.

EDWARD P CONNELL, 56, secretary-treasurer and general manager of Falk Corp, Milwaukee, Wis., died Feb 8 after a short illness. Mr Connell had been with the Falk Corp for 28 years, starting as accountant in 1913 and later serving as purchasing agent and comptroller. He was appointed treasurer in 1939 and was named general manager in 1940.

FRANK J HOLDERRIED, 74, president, general manager and treasurer of the Kendall Boiler & Tank Co, Cambridge, Mass., died at home in Newton, Mass., on Feb. 21. He had been in the boiler industry for over 50 years.

PERSONALS

K P ROLSTON, formerly chief engineer of the Screw Machine Specialty Co, Pittsburgh, Pa., has accepted the position of works manager in charge of mechanical production of Hunter Mfg Corp, Bristol, Pa., which is engaged in ordnance work.

S J MCDOWELL has joined the engineering staff of American Lava Corp, Chattanooga, Tenn. Since his graduation from the College of Ceramics at Ohio State University Mr McDowell has been associated with the AC Spark Plug Div, General Motors Corp, Corning Terra Cotta Co, General Ceramics Co, and the U.S. Bureau of Standards.

J C MERWIN, vice-president and treasurer, Chain Belt Co, was recently elected president of that company, succeeding the late C R Messinger, who died February 4. Mr Merwin joined the organization in 1917 and has been successively superintendent, works manager, assistant to president, director, vice-president and treasurer.

T I PHILLIPS has been appointed assistant to the president of the Westinghouse Electric & Mfg Co. Mr Phillips, formerly general works manager, will continue to be in charge of headquarters manufacturing staff, Small Motor, Lighting and Transformer Div, and Construction Dept of the company, with headquarters in Pittsburgh.

ERNEST C LOW has been appointed general manager of sales of John A Roebling's Sons Co. Mr Low has been identified with the Roebling organization for 32 years, having joined the

WHERE TUBES MUST BE RELIABLE
for service 24 hours a day
To guard against service interruption, most Central Stations use B&W Seamless Steel Boiler Tubes.
B&W pioneered in the development of seamless steel tubes for high-pressure, high-temperature steam to keep B&W Boilers dependable, safe and economical.
Ample stocks and split-second service facilities are maintained.
BABCOCK & WILCOX TUBES
HOT FINISHED COLD DRAWN ALLOY STEELS CARBON STEELS
THE BABCOCK & WILCOX TUBE COMPANY, BEAVER FALLS, PA.

ADVERTISING MATTER REMOVED

They WEAR themselves into perfect condition

SEA-RO GRAPHITIZED
PUMP PLUNGER RINGS No. 528

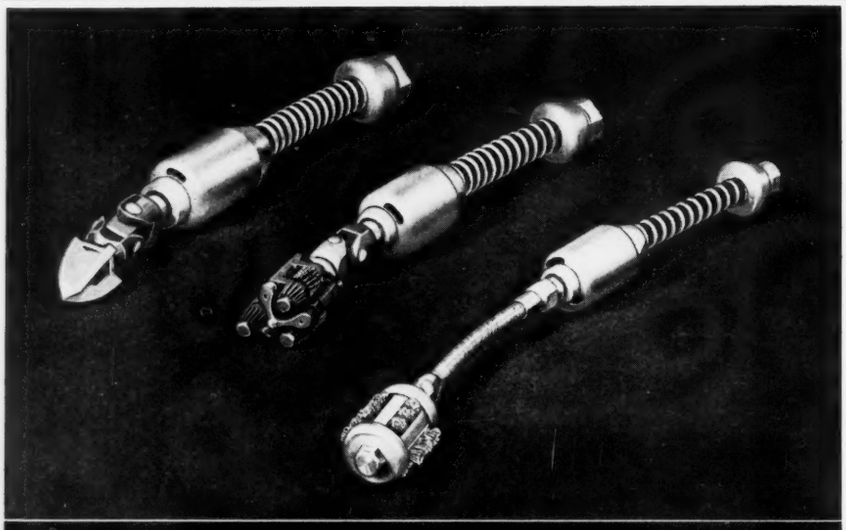
Tests prove that Sea-Ro Graphitized Rings acquire a hard glass-like surface after long operation, and being of a floating type, reduce wear on cylinder liners.

Sea-Ro No. 528 Rings are recommended for plungers of pumps handling hot or cold water, oils, gasoline, solvents, ammonia, etc.

For large heavy-duty pumps, use Sea-Ro No. 525 Rings, with patented internal expansion spring.

Send for detailed information.

SEA-RO PACKING CO., INC., WOOD-RIDGE, N. J.



TIME SAVED IN CLEANING TUBES MEANS LOWER PRODUCTION COSTS

Speed—speed in travel, communication, production—is the demand of today. Speed in cleaning the tubes of power plant boilers, superheaters, economizers, etc. reduces plant shutdowns, assures maximum power development and thus speeds up and increases production. Because of their proved speed and efficiency Wilson tube cleaners are used in hundreds of plants engaged in the production of equipment essential to our national defense.

A Wilson C T Series Air or Steam Motor (illustrated above) designed especially for cleaning curved tubes from 2½" O. D. to 4" O. D. with short radius bends will save you time, trouble *and* tubes when used with the correct Wilson accessory.

Write for the name of our representative nearest to you or for a copy of our thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
47-28 37th Street Long Island City, N. Y.

California Div at Los Angeles upon his graduation from college in 1909. He was appointed manager of San Francisco branch in 1930 and in 1940 was elected president and general manager of John A Roebling's Sons Co of California.

ALONZO M HARP was recently appointed assistant sales manager of De-Bothezat Ventilating Equipment Div, American Machine & Metals, Inc. Mr Harp has served in the manufacturing, engineering and sales departments of the organization since 1929 and the past three years he has been sales manager of the central division.

FRED L WITSELL, Toledo Edison Co, who became president of the National District Heating Assn in May 1940, was recently made president and general manager of the Pueblo Gas & Fuel Co, Pueblo, Colo. Because of this transfer, Mr Witsell resigned as president of the Association.

J G HOLTZCLAW, president of Virginia Electric & Power Co, has been named a district coordinator of the defense contract service, it was announced March 4 by the Office of Production Management, Washington, D. C.

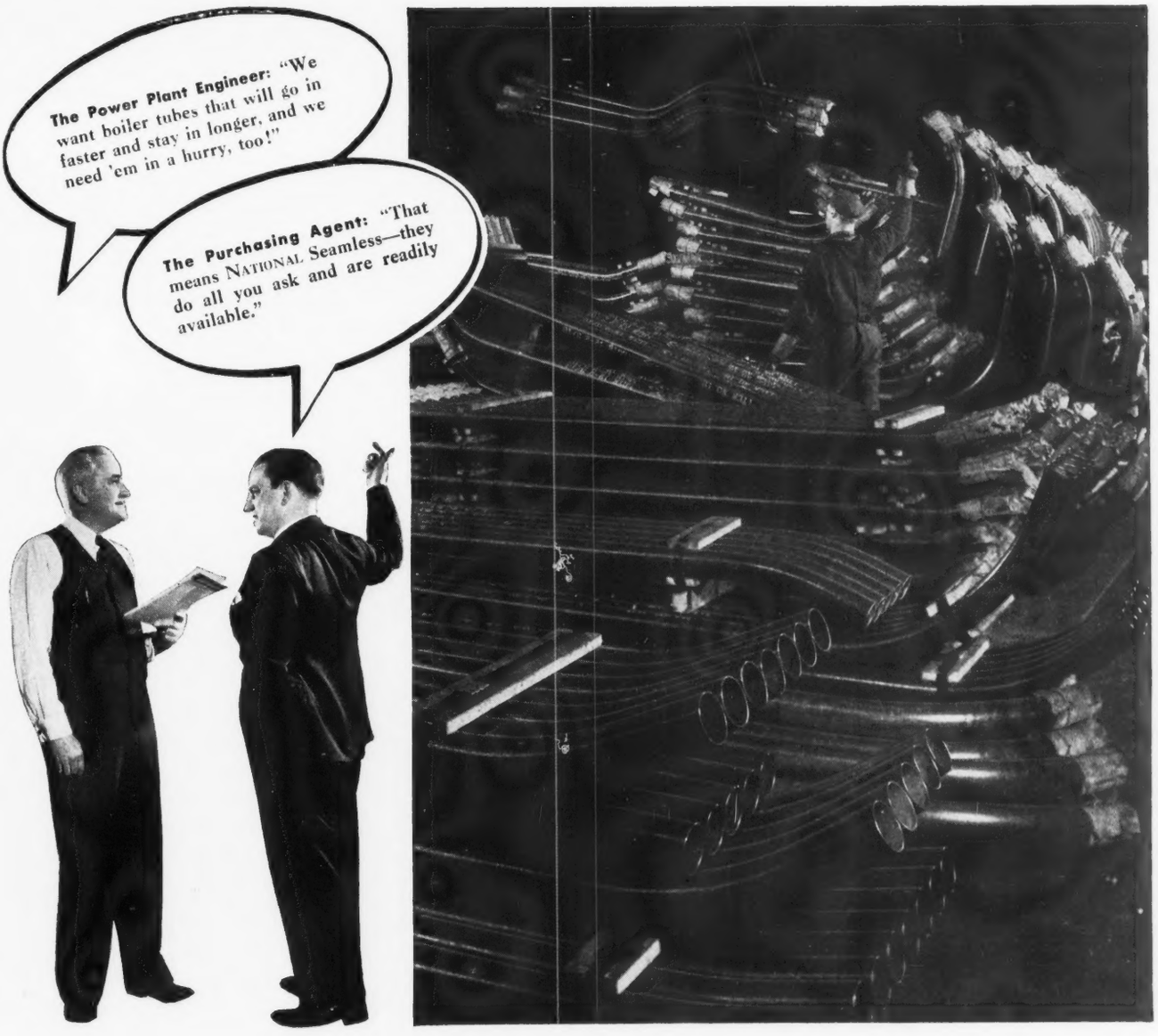
E K SWEENEY has been appointed Philadelphia area district manager for McQuay, Inc, Minneapolis, Minn. For the past four years Mr Sweeney was a member of the firm of Breitenbach and Sweeney, Trane representatives; and previously was co-manager of Trane Co, Philadelphia Branch office.

STEWART J HIERONYMUS was recently named to the staff of Lincoln Electric Co, as sales engineer in the San Francisco office. Prior to his appointment, Mr Hieronymus was associated with Cutler-Hammer, Inc, for 12 years.

E C LUSK has joined the technical staff of Battelle Memorial Institute, Columbus, Ohio. He is assisting with the various ore-dressing and coal-preparation investigations in progress at the institute.

HARRY A BURDORF and FRANK P RHAME, vice-presidents of the Lunkenheimer Corp, Cincinnati, Ohio, were elected to the board of directors at a meeting Feb. 27. Burdorf, who has been with the company since 1905, is vice-president in charge of sales, and Rhame, who has been with Lunkenheimer since 1919, is vice-president in charge of sales engineering.

ADDISON C ARMSTRONG has joined the Worthington Pump & Machinery Corp at its Holyoke, Mass., works, as


The Power Plant Engineer: "We want boiler tubes that will go in faster and stay in longer, and we need 'em in a hurry, too!"
The Purchasing Agent: "That means NATIONAL Seamless—they do all you ask and are readily available."

. . . and another big boiler job is on its way!

TIME is a big factor these days, and whether you are building a new high-pressure boiler or retubing an old boiler, you'll find that the safest, strongest tube is the best investment. That's why so many engineers are specifying NATIONAL Seamless Boiler Tubes. *They speed up the job, save time and money on installations, give you safe, efficient service.*

The reasons are simple — every NATIONAL Seamless Boiler Tube is 100% annealed, a homogeneous cylinder pierced from a solid billet of the finest quality killed, open-hearth steel. Uniformly soft and ductile, easy to flare, roll and bead—and capable of withstanding all regular forming operations without a tendency to crack or split. The results are invariably fast, tight installations of high physical strength that stand the strain of excessive loads in these days of unusual demand.

Get the facts today! For maximum safety and economy it will pay you to standardize on NATIONAL Seamless Boiler Tubes. Take advantage, also, of the practical field service National has available to boiler tube users. A representative will be glad to help you with your problems. No obligation. Write for Bulletin No. 10.

NATIONAL TUBE COMPANY

PITTSBURGH, PA.

Columbia Steel Company, San Francisco, *Pacific Coast Distributors* · United States Steel Export Company, New York

UNITED STATES STEEL

THE ACCURACY AND PERFORMANCE OF A PROPORTIONING PUMP DEPEND ON THESE FEATURES

For improved accuracy in the feeding of treating chemicals for the prevention of scale, corrosion foaming and embrittlement in boilers and steam generators, %Proportioneers, Inc.% now offer a complete line of Adjust-O-Feeders with these new important construction features:

1. Oversize cross head guide with drip feed lubrication and visible stroke length scale. Fig. 3
2. Oversize micrometer screw for ease in adjusting exact crank throw. Fig. 4
3. Heavy Torrington needle bearings on both crank pin and wrist pin. Crank pin has hardened replaceable inner and outer races; wrist pin is automobile standard case hardened with replaceable outer races. Fig. 5

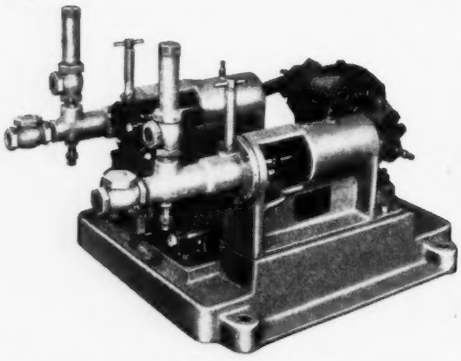


Fig. 1—Standard Adjust-O-Feeder for pressures up to 250 lbs. Capacities from 5 gph. to 10 gpm.

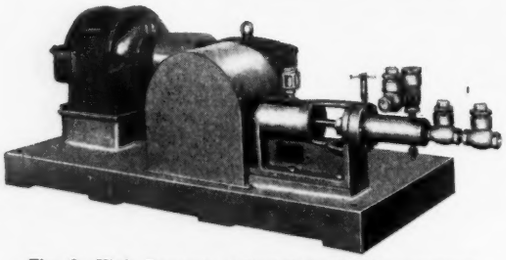


Fig. 2—High Pressure Adjust-O-Feeder for pressures up to 2500 lbs. Capacities from 2 gph. to 2 gpm.

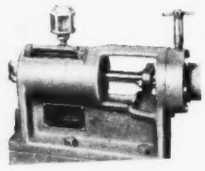


Fig. 3—Cross head guide with visible stroke length scale.

Fig. 4—Micrometer crank arm with adjusting screw.

Fig. 5—Connecting rod assembly showing needle bearings.

For maximum efficiency and protection of your steam generating equipment, investigate the accuracy, simplicity, dependability, and low operating cost of %Proportioneers% Chemical Feeding Equipment.

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manager of the Ordnance Div. He will be directly in charge of the production of ordnance equipment at that plant. Mr. Armstrong was formerly affiliated with the Truscon Steel Co as departmental manager.

JOHN E FEARON, formerly in charge of Flow Meter Sales Section, Appliance Div, Cochrane Corp, has joined the Boiler Equipment Service Co, Atlanta, Ga. He is a graduate of Franklin and Marshall College.

BUSINESS ITEMS

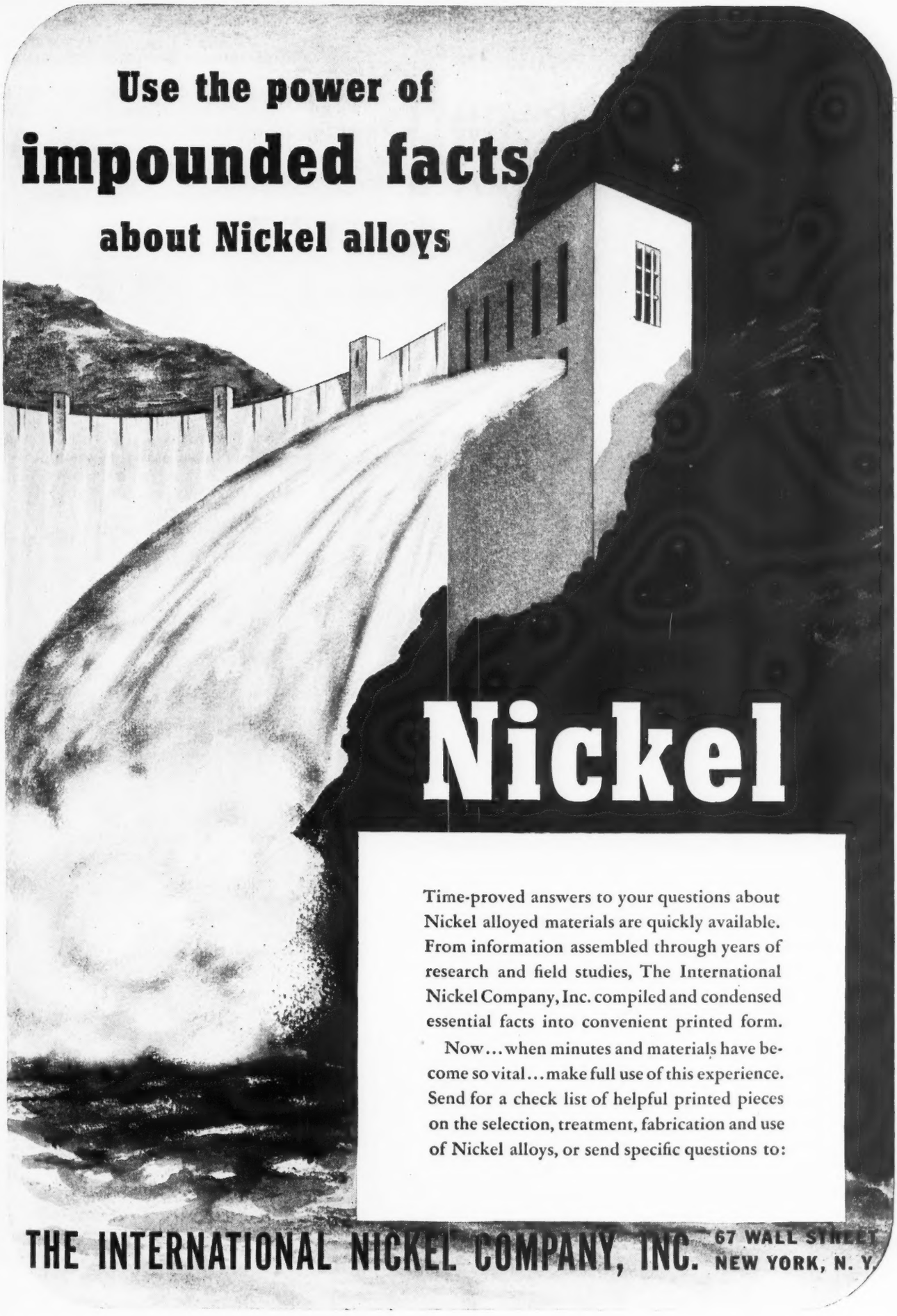
W H & L D BETZ has opened new district offices, in St Louis, Mo., at 455 Brown Bldg, and in Cincinnati, Ohio, at 831 Temple Bar Bldg. Montreal address of Betz Laboratories Div, Wood Industries Supply Co, Ltd, is 2009 Royal Bank Bldg, and in Toronto is 1207 New Wellington Bldg. W A Krebs has been assigned to Greensboro, N. C., district; Francis Markson has been sent to Savannah, Ga.; Albert E Hall to Birmingham, Ala., and H C Campion, sanitary engineer, to Grand Rapids, Mich.

GEORGE SCHERR Co, 128 Lafayette St, New York, N. Y., has been appointed exclusive sales representative for the Wilder micro-projector, manufactured by R S Wilder, Inc, Waltham, Mass.

HOBART BROTHERS Co, Troy, Ohio, has appointed H F Schotters to supervise distribution of Hobart arc welders in northern Indiana and western Michigan.

ENTERPRISE ENGINE & FOUNDRY Co, San Francisco, announces appointment of B Stockfleth as assistant to the president, C G Cox as vice-president in charge of sales, Hans Bohuslav as vice-president in charge of engineering and C M Sayre as vice-president in charge of production. Mr Stockfleth was formerly with Soulé Steel Co, Cox came to Enterprise in 1934, Bohuslav has been with the company for eight years, and Sayre joined the organization in November, 1940.

TIMKEN ROLLER BEARING Co, Canton, Ohio, has made several shifts in personnel. F H Lindus, formerly Los Angeles branch manager has been transferred to the home office at Canton, Ohio. L J Halderman, branch manager of Service-Sales Div, Chicago office, has taken Mr Lindus's place at Los Angeles, while Jack Gelomb, formerly Detroit manager of Service-Sales Div, has filled the vacancy in Chicago. Joe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Time-proved answers to your questions about Nickel alloyed materials are quickly available. From information assembled through years of research and field studies, The International Nickel Company, Inc. compiled and condensed essential facts into convenient printed form.
Now... when minutes and materials have become so vital... make full use of this experience. Send for a check list of helpful printed pieces on the selection, treatment, fabrication and use of Nickel alloys, or send specific questions to:
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NOW IS THE TIME TO

STOP THESE SABOTEURS

Let SANTOBRITE control SLIME and ALGAE before they reduce the efficiency of your cooling water system!

Right now is the time to start treatment of your cooling water system with Santobrite . . . before the algae season reaches its peak and you are faced with a sizeable bill for cleaning adherent, insulating growths out of your condensors!

Santobrite (sodium pentachlorophenate) was developed by Monsanto for use in recirculating cooling water systems where the water is not used for drinking or bathing. Highly toxic to algae and other slime-forming organisms, easy to handle and apply, low in cost, Santobrite keeps the system free from growth . . . makes for peak efficiency at all times.

Preventive treatment with Santobrite early is much simpler and less expensive than treatment to destroy accumulated growth. Write today for a copy of Monsanto Technical Bulletin 0-15, "Santobrite for the Control of Slime and Algae." MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, St. Louis, U. S. A. District Offices: New York, Chicago, Boston, Detroit, Charlotte, Birmingham, Los Angeles, San Francisco, Montreal.

QUICK FACTS ABOUT SANTOBRITE

1. Essentially unreactive chemically . . . stable in presence of organic and inorganic substances.
2. In concentrations used for algae control, will not attack metals commonly used in engineering practice.
3. Compatible with other water treatments.
4. Uniformly effective as an algaecide throughout pH range found in cooling practice.
5. Available in one-ounce briquettes, 7 pounds to a cotton bag, 10 bags to a container.
6. Can be applied by simply suspending bag in cooling water.

Detailed information in Technical Bulletin 0-15.

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SERVING INDUSTRY . . . WHICH SERVES MANKIND

Jesseph, resident salesman in Portland, Ore., branch, has taken Mr Gelomb's place in the Detroit district.

CHICAGO PIPE WELDING CO, 205 W Wacker Drive, Chicago, Ill., announces new pipe-cutting service in which they will furnish pipe cut to measure, with ends shaped, fitted and beveled, ready for welding.

NATIONAL ALUMINATE CORP, Chicago, Ill., announces following appointments as junior salesmen: F J Barnett and B J Lamb, in Texas territory under E F Fellows; C H Van Riper under R G Stewart, with headquarters at Knoxville, Tenn.; and R W Cover in Pittsburgh area under H R Powers.

BROWN INSTRUMENT CO, Philadelphia, Pa., has published its 1941 calendar. Cartoons drawn by Bill Eddy, whose work also appears in POWER, illustrates humorous situations, and POWER data sheets are included with each month. Company will send to any reader requesting same on company letterhead.

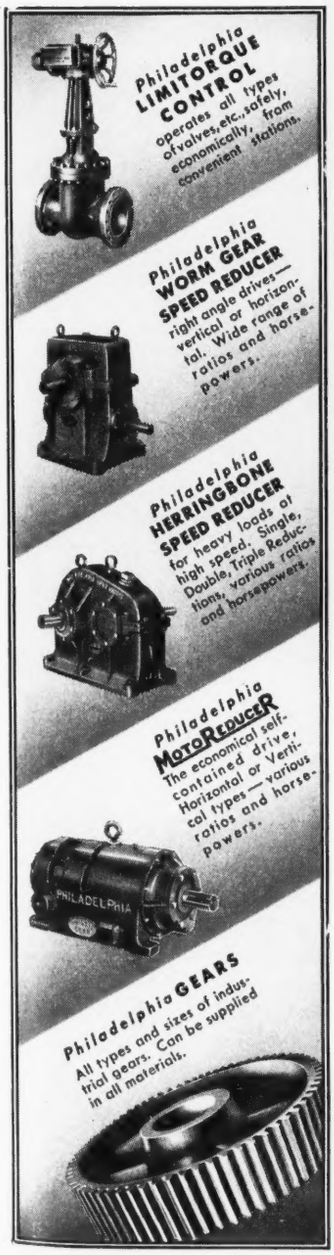
B F GOODRICH CO, Akron, Ohio, announces several changes in its mechanical division. A W Doran has been assigned special duties in connection with railroad and governmental sales. B E Silver, sales representative of the mechanical division in Indiana, has been transferred to government sales in Washington, with W E Nees appointed to replace him, with headquarters in Indianapolis. Ralph Barcus of the Akron district staff succeeds Nees in West Virginia, with headquarters in Charleston.

VAN DER HORST CORP OF AMERICA recently organized by Hendrik Van der Horst, introduces patented process of "porous chrome hardening" for cylinder walls, pistons, etc. Process is result of experiments based on theory that engine wear was caused by corrosion instead of friction. First concern established was in England, where process is said to be widely in use. Two plants in U.S., American Hammered Piston Ring Div of Koppers Co, and Naval Aircraft Plant at Philadelphia, are already operating under Van der Horst licenses.

SEAMLESS STEEL TUBE INSTITUTE, Pittsburgh, Pa., announce adoption of program of market research and related activities under direction of W A Cather, former advertising manager, Babcock & Wilcox Co, New York. Program went into effect March 1.

General committee of DIESEL ENGINE USERS ASSN, London, England, an-

" . . . AND THEY'RE ENTHUSIASTIC ABOUT THE PLANETORQUE FEATURE, TOO?"
"THEY SURE ARE . . . IT'S ALREADY SAVED THEM MUCH TROUBLE AND EXPENSE."
PHILADELPHIA


Philadelphia LIMITORQUE CONTROL operates all types of valves, etc., safely, economically, from convenient stations.
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Philadelphia GEARS All types and sizes of industrial gears. Can be supplied in all materials.

The PlaneTorque feature attached to any Philadelphia MotoReduceR —horizontal or vertical—provides real insurance against damage from overloads to the drive and driven machinery alike. Motor current is automatically and instantly cut off when the load reaches a predetermined value. Yet the PlaneTorque MotoReduceR may be started again by removing the excessive load, without re-setting the switch. This adequate protection plus the ease of re-starting makes the PlaneTorque MotoReduceR a definite time and cost saver in production plants. Write us today for more complete details.

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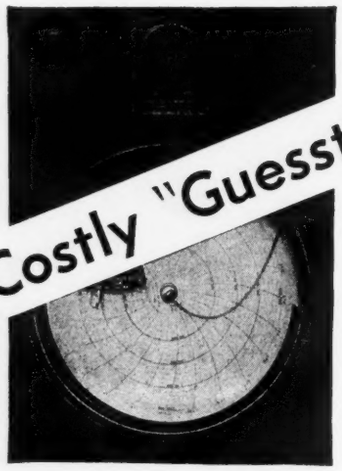

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Extra Strength . . . . for Heavy Duty

Wherever heavy duty demands extra strength . . . Kewanee Steel riveted boilers are preferred. For the known strength assured by **Steel + Rivets,** supplemented by extra stout stays and braces in the boiler shell, mean many added years of service.

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With hundreds of typical examination questions and answers as well as complete instructions, this book presents fully and plainly the things you want to know about proper installation, operation, and care of boilers—the things that prevent dollars of loss in reduced efficiency, breakdown, or even accident.

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241 illustrations
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Send me Spring's Boiler Operator's Guide for 10 days' examination. In 10 days I will send you $3.00, plus few cents postage or return book postpaid. (We pay postage on orders accompanied by remittance.)

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nounces that Percy Still Medal for 1939-40 session has been awarded to Messrs T Hornbuckle and A K Bruce, for their paper on "Herbert Akroyd Stuart and the Development of the Heavy Oil Engine."

SIMPLEX VALVE & METER Co, Philadelphia, Pa., has appointed Mr George Goodman as exclusive representative in Maryland, District of Columbia and northern Virginia. Mr Goodman was associated with the New York office of the Brown Instrument Co for a number of years.

JOHNS-MANVILLE, INC, has established new industrial departmental office in Atlanta, Ga., to serve the states of Georgia, Tennessee, North Carolina, South Carolina, Florida, Alabama and Mississippi. Office will be in charge of Thomas J Roberts.

Developments on Speed Governors

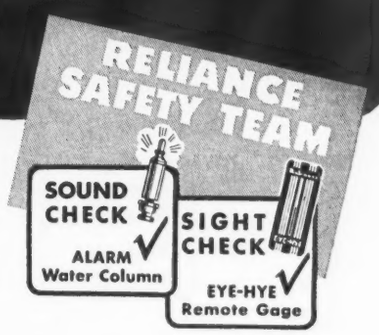
SPEED GOVERNORS on steam and hydro turbines operating on large inter-connected power systems, which are now of increased importance from the standpoint of national defense, were discussed by R J Caughey and J B McClure, of the General Electric Co, before the American Institute of Electrical Engineers' winter convention at Philadelphia. The authors pointed out that system operating requirements, from the standpoint of frequency and tie-line loading, are continually becoming more rigorous and receive more widespread attention. Supplementary controls have been developed to assist in the solution of these problems, but the speed governors or the prime movers still constitute the backbone of system control.

The following conclusions which apply to the refinement of both steam and hydro turbines were said to have been reached in regard to speed governors after consideration of operating requirements, nature of load changes on large systems, reliability of operation, simplicity in mechanism, and ease of maintenance.

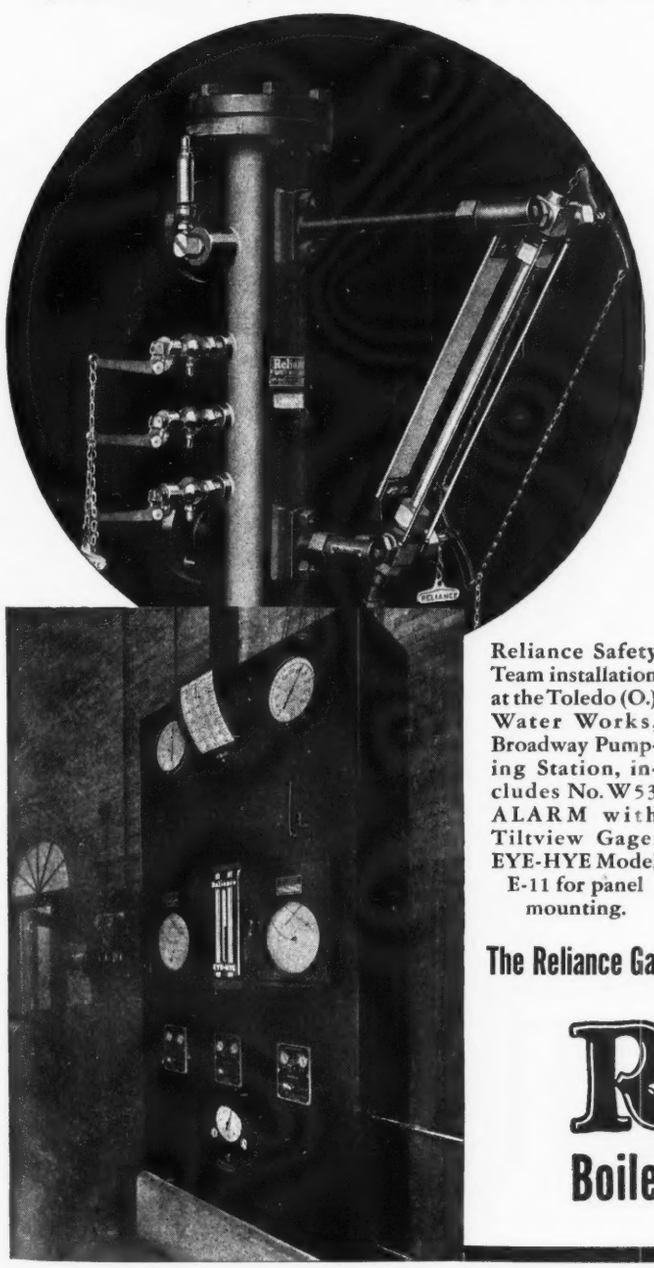
One of the first and axiomatic requirements is that the governing mechanism be stable at all times. A stable governor is one which does not, by itself, produce or excite an oscillation. A governor with a high degree of stability is effective in quickly reducing the magnitude of oscillation produced by any disturbance. Small dead bands, broad incremental regulation, both transient and steady-state, and small

The cry is "PRODUCE MORE"

Don't let power failure force you to produce less!



Reliance Safety Team gives you supervision of your water levels that prevents boiler outage



Reliance Safety Team installation at the Toledo (O.) Water Works, Broadway Pumping Station, includes No. W53 ALARM with Tiltview Gage; EYE-HYE Model E-11 for panel mounting.

If you would conserve every valuable production minute — keep power flowing efficiently — apply all the safety factors that it's common sense engineering to use. *Safe water level supervision* by the Reliance Safety Team costs nothing compared to time-wasting shutdowns and expensive accidents.

This is the modern way — the Reliance *double check* through SOUND and SIGHT.

- The ALARM Water Column calls boiler operators to *action* if water levels reach unsafe stages — sounds a warning whistle, or electric signals anywhere in the plant. Sensitive response and ability to take punishment has characterized Reliance ALARMS for 56 years.
- The EYE-HYE Remote Indicator makes frequent reading of the true water level so convenient that there's little chance for extreme conditions to develop. More accurate than the usual boiler gage, it brings checking down to operating floor — *at eye level.* Its green indicating fluid is illuminated — a brilliant column on panel or wall, easily readable at a distance.

This is the Reliance Safety Team — a pair of sentinels you should know more about if you're not one of the thousands of Reliance users who are confident they'll not produce *less* through lack of water level supervision. Write today for ALARM and EYE-HYE Bulletins.

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Do you want to KNOW

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should be used to accurately measure such ordinarily "hard-to-measure" liquids as BOILER FEED WATER, HOT DIRTY BLOW-DOWN, CONDENSATE, FREE RUNNING CHEMICALS, and many others?

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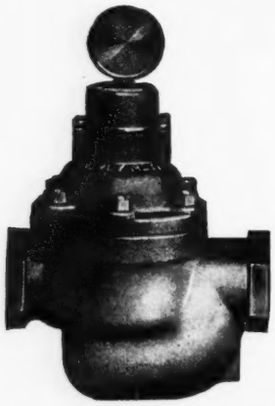
- **Meters can be calibrated to read in Gallons, Pounds, or Cubic Feet, at any specified temperature.**
- **Sizes; 10 to 600 G.P.M. cold water, steady flow rating. Connections: ¾" to 4". Special sizes to order.**



Don't delay—write for more information stating your specific problem. No obligation for recommendations.

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HENSZEY

time lags, all contribute to stability and are largely under the control of the designer.

Generally, if the unit is stable for synchronizing, it will be still more stable when connected to a system, due to synchronizing and damping-torque action provided by the system. For the same reason a governing mechanism which is poor when operated alone may give no trouble when it becomes part of a system already equipped with good governors.

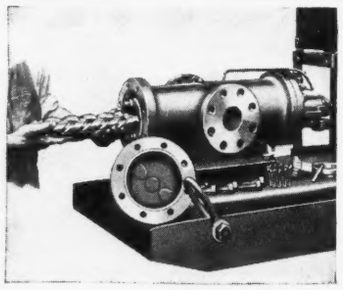
Dead band, which is the magnitude of the sustained speed change within which the governor will not cause a change of prime-mover input, should be as small as practical.

Incremental regulation is the slope of the speed-kilowatt curve passing through 100% speed at the load in question, expressed in percent of rated speed. This in the normal operating range should be as uniform as is consistent with economical design of the mechanism and efficient turbine operation. By making the incremental regulation as uniform as possible, and as large as necessary, stability margin at all valve points is assured and more uniform response to supplementary adjustment is obtained.

If improved uniformity is obtained entirely through mechanism design, more powerful operating cylinders may be necessary, or more complicated mechanism may be required. If improved uniformity is obtained by increased overlapping in valve openings, turbine efficiency is reduced at these points. Incremental regulation should be as broad as is consistent with reasonable system speed variations. Broad regulation improves stability, contributes to most rapid settling down after a disturbance, and minimizes any tendency for hunting which might be caused by dead band. Uniform incremental regulation is desired, but not essential.

Over-all regulation is the sustained percent change in speed of a prime mover for full-load change from an initial speed of 100%. With steam turbines the maximum over-all regulation which can be tolerated and still meet the present overspeed- and emergency-trip requirements is about 6%, and the minimum over-all regulation for stability is in the order of 2 or 3% without droop correction. For this reason it is believed that some reasonable over-all regulation in this range can be used for most steam-turbine mechanisms, thus avoiding the added complications of adjustable regulation.

An advantage in operating on small



The three moving parts of the DE LAVAL-IMO OIL PUMP

can at once be withdrawn upon removing the end cover and releasing the coupling half. There are no valves, no timing gears and only one stuffing box, which is under suction pressure only. Simplicity in construction is matched by smoothness in operation, there is no vibration or pulsation, and the pump can be coupled to a standard speed motor or turbine.

Write for Catalog I-74.

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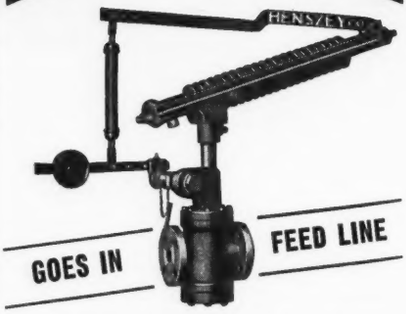

The Henszey Boiler Feed Regulator controls boiler water levels continuously and accurately under *all* load conditions!

These simple, compact, self-contained units go right in the feed line and require no additional structural support. They are as easy to install as a simple gate or globe valve. Once installed and set for operation no further attention is necessary — nothing to get out of order — nothing to reset.

Send for latest Bulletin containing full details.

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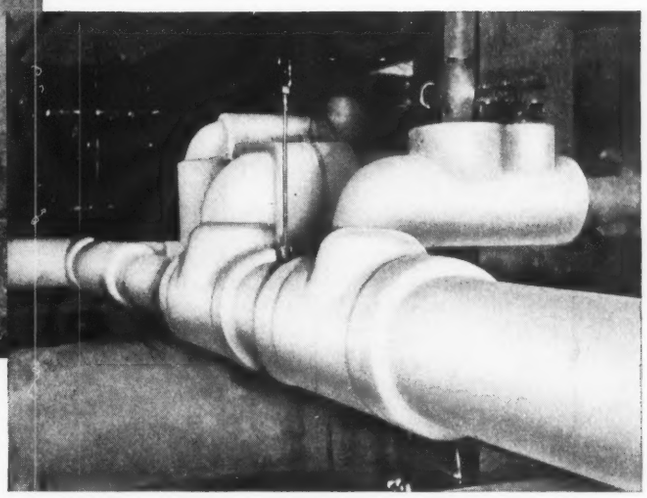
K & M INSULATION BRINGS 54% YEARLY RETURN

Bare pipe flanges prove costly to Equitable Life Insurance Company of Iowa Building



Office building of the Equitable Life Insurance Company of Iowa, Des Moines, Iowa, in which the application of the correct K&M insulations not only materially reduced fuel cost, but prevented loss of rental income. In center foreground of illustration at right are shown the removable-replaceable flange and fitting covers. Insulation applied by Insulation Engineering Co., Des Moines.

THE Equitable Life Insurance Company of Iowa had believed the boiler room of its building to be adequately insulated . . . but the pipe flanges had been left bare. To insulate them had looked like more trouble than it was worth. It was quickly proved, however, that bare flanges can be costly.

Following an engineering survey, the boiler room of the building was reinsulated for higher efficiency, using Keasbey & Mattison "Featherweight" 85% Magnesia. Being a well engineered job, this one naturally included all pipe flanges. Even with the use of low-cost fuel, the saving *at these points* is sufficient to pay a 54% yearly return on the cost of insulating the flanges!

In addition, this building found that the efficiency of the K&M insulation safeguards valuable first-floor store space against boiler room heat, helping to insure rental income. This is typical of the way K&M insulations are saving heat, fuel and dollars for business and industry the nation over.

K&M engineers, working with K&M Distributors strategically located throughout the country, can point the way to real savings in your plant, too. Write Dept. 11 for full details.

K & M "Featherweight" 85% Magnesia

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COMPANY, AMBLER, PENNSYLVANIA

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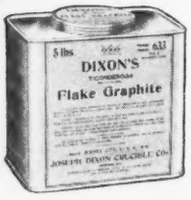
THE *ENDURING* LUBRICANT



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No. 635: Minutely subdivided powdered flake graphite for close tolerance applications.

Microfyne Flake Graphite: Processed to microscopically subdivided particle size. Meeting requirements calling for the smallest particle subdivision in a commercial grade.

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Avoid accidents! Prevent costly delays! Repair holes, cracks, broken places in concrete floors or resurface an entire area with the durable RUGGEDWEAR RESURFACER. No chopping or chipping required. Merely sweep out spot to be repaired—mix the material—trowel it on. Holds solid and tight right up to irregular edge of old concrete. Cellulose-Processed to provide a firmer, tougher, smoother, more rugged wearing surface. Used indoors or out. Dries fast. Costs only 10c to 14c per sq. ft.

Valuable 74-page "HAND BOOK OF BUILDING MAINTENANCE" available to those requesting on business letterhead.

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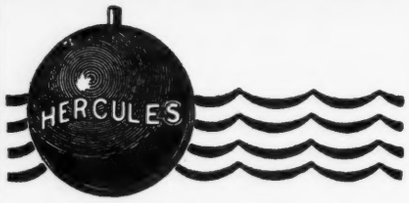

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overload regulation might be to reduce slightly the duty of the supplementary corrective devices now employed, but it appears as though there is a good chance of creating a wider frequency fringe by attempting to operate the units of an entire system on small overall regulation, because of the reduced degree of stability obtained. The authors draw the conclusion that adjustable regulation is not necessary.

The present rates of response of steam and hydro governors are widely different, and this results in a corresponding redistribution of power flow subsequent to load changes. Usually, sudden load changes on most large systems are relatively small, and the major load changes occur at a rate which can be followed by even the slowest mechanism. In an interconnected system all active governors respond to all load changes, regardless of location, in proportion to their ability, and in principle it is the function of supplementary control (manual or automatic, or both) finally to allocate a load change in any area to generation in the same area. Any redistribution of load, due to different governor characteristics, is so masked by real load changes that it is not considered important to modify designs in order to match governor characteristics, therefore similarity of rate of response is not necessary.

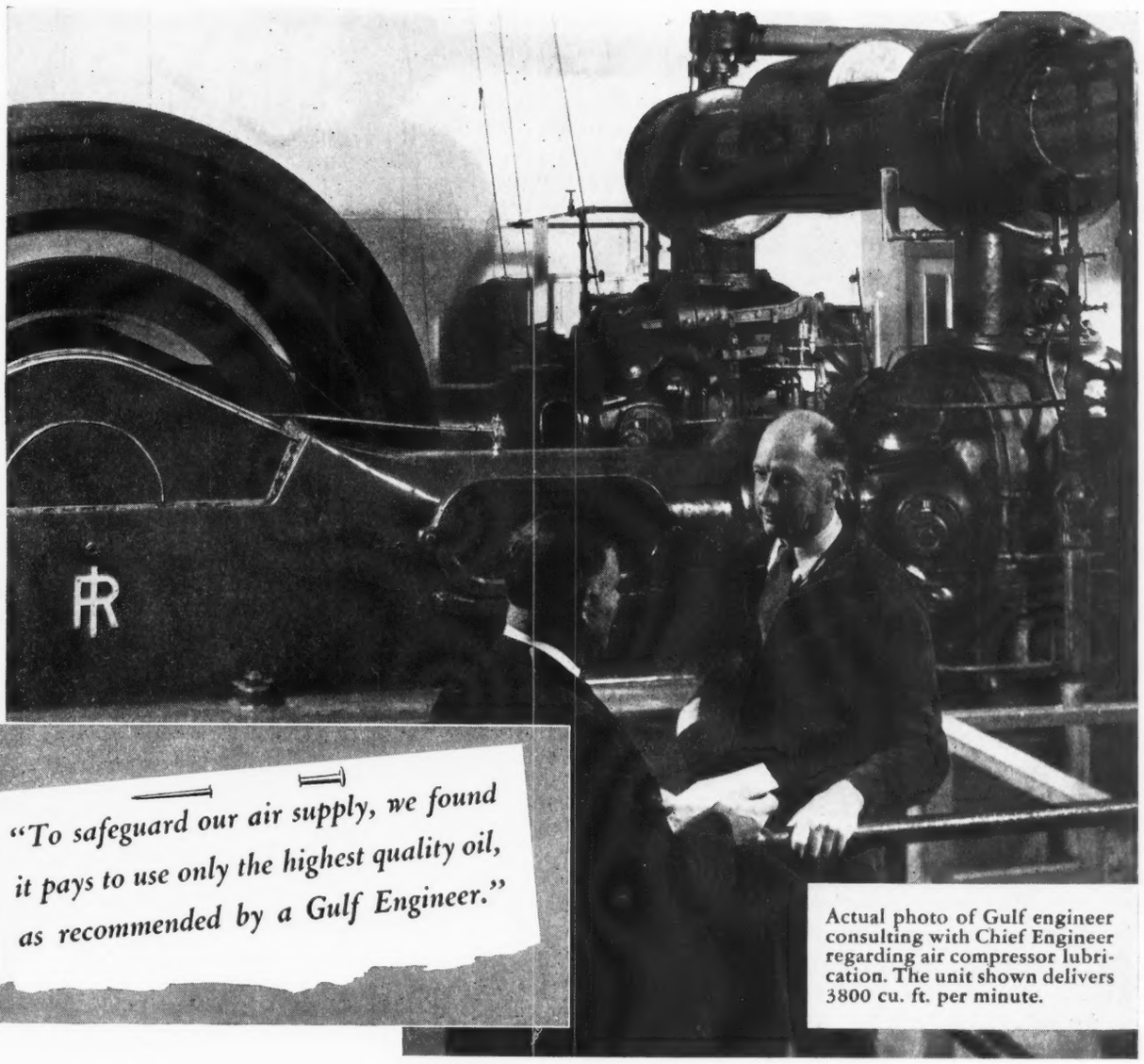
Supplementary adjustment, any means employed to adjust externally the prime-mover input, is provided on all speed governors and may be used for either manual or automatic correction. This adjustment should be arranged so that reasonable uniform response is assured throughout the operating range, and is something that is desirable in the governing system, along with accurate response.

Indications of all adjustments on the governor system are desirable. Gage-position indicators have been available on hydro units for some time, and indications of operating piston positions on steam units, with valve opening points has been suggested. Gage indications on hydro units are often more useful than a wattmeter, particularly on a variable-head installation, and on a steam unit it is desirable to avoid operation at partial valve openings.

For smaller systems governing mechanisms which can, if desired, be operated at zero steady-state regulation, may have a distinct field of usefulness. For governing mechanisms on the large systems, emphasis should be placed on obtaining uniform incremental regulation, accurate response for supplementary control, and small dead band.

"We solved our compressor lubrication problems with GULF HARMONY OIL "C"

Says this Chief Engineer



"To safeguard our air supply, we found it pays to use only the highest quality oil, as recommended by a Gulf Engineer."

Actual photo of Gulf engineer consulting with Chief Engineer regarding air compressor lubrication. The unit shown delivers 3800 cu. ft. per minute.

"WE get trouble-free operation from our compressors since we standardized on Gulf Harmony Oil C" says this Chief Engineer. "We have to insure a dependable air supply for underground work in our mine—that's why we take advantage of the expert lubrication advice of the Gulf engineer."

Are you seeking more dependable operation of your mechanical units? The trained Gulf lubrication engineer in your vicinity can help you. He has a background of broad experience in lubricating all types of equipment similar to yours—an experience which can be translated into greater efficiency in your plant. And you pay nothing extra for his co-operative service.

The Gulf line of more than 400 quality oils and greases is quickly available to you through 1200 Gulf warehouses in 30 states from Maine to New Mexico. Write or phone your nearest Gulf office today.

GULF INDUSTRIAL LUBRICATION

GULF OIL CORPORATION · GULF REFINING COMPANY · PITTSBURGH, PA.

WHAT "TOUGH" Packing Job Have You?

TRY "AMBEST"

A universal packing for all rods in good condition—made from long pliable strands of anti-friction metallic alloy—suitable for all pressures and temperatures up to 550°. Will not scratch the finest rod. Single supply will allow packing engine and pump rods, compressors, valve stems, etc.

For Worn or Scored Rods

"Eureka" Oval Gum Core can be used on any rod (except high pressure steam) and will give better and longer service. Is oval and soft—conforms to the rod—permits more rings in stuffing box—recommended for steam, air, gas and ammonia.

Write for working sample and our catalog No. 22

EUREKA PACKING CO.

294-296 46th Street, Brooklyn, N. Y.

WATER REFINING EQUIPMENT HEADQUARTERS

INDUSTRIAL—PROCESS
RAILROAD—MUNICIPAL—HOUSEHOLD

SPECIALIST...

for more than two decades . . . in designing and manufacturing the mechanical equipment for ZELOLITE (synthetic and natural) water softening systems.

The easily reached and operated Nest of Control Valves facilitates change of flow direction, when conditions so require.

Single Valve Control is available if desired.

Write for other exclusive American advantages.

The AMERICAN WATER SOFTENER COMPANY

WATER REFINING EQUIPMENT HEADQUARTERS
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322 LEHIGH AVE., PHILA., PA.

Semi-Conducting Rubber Eliminates Static

By A E JUVE

Technical Department

B F Goodrich Co

PHENOMENA ASSOCIATED with the accumulation and discharge of static charges are experienced by everyone. Aside from lightning, the most common experiences are probably the evidences of static charges in combing one's hair, scuffing of the feet on a dry carpet, separating two sheets of paper, and many similar occurrences. These phenomena are usually unobjectionable, though they may be a nuisance and often extremely uncomfortable. In many cases, however, particularly in industry, the discharge of a static accumulation in the presence of inflammable solvents or dust mixtures can be extremely hazardous.

Static charges may be developed in a variety of ways. Primarily, friction between two insulating materials or within an insulating liquid or gas is required. Static charges may also be developed in the absence of friction as when a liquid is broken up into small particles or a mist, or when a mist coalesces into larger particles.

Grounding Static

An article, when charged, may be discharged by grounding to the earth with a conductor or by contact with a body of opposite charge. In both cases the discharge, if the potential is sufficiently high, is accompanied by a spark. Its charge may also leak off slowly to the ground through humid air. The higher the humidity, the faster the rate of discharge.

It has been reported that static-generated fires in rubber-coating plants are practically unknown at humidities exceeding 50%. Moderately good conductors, which are in turn grounded, may also be used to bleed off an accumulated charge without the violence and spark that would accompany a high resistance discharge.

In many rubber applications, problems concerned with the generation and dissipation of static charges are important. Since normally compounded rubber is an excellent insulator, rubber products, which in service are subjected to frictional forces applied through or by another insulating material, will accumulate static charges.

This industrial bogeyman is especially active in factories which use belting. The uncontrolled discharge of

Save Air—Save Dollars

Flanged Slide Type

IT'S like putting money in the bank to replace old style blast gates—the kind that leak, waste power, and "make up" a wobbly line—with Rockwell Blast Gates. These gates have many features that make them the outstanding "buy" in all branches of industry.

Write for Catalog No. 4020

W. S. ROCKWELL COMPANY

Blast Gate Division

50 CHURCH STREET NEW YORK, N. Y.

Do you realize

that 85% of all Furnace Repairs or Rebuilding are necessary because of spalling or loosening of the brick. This means many firms are spending considerable for replacement materials and labor that could be saved by laying-up brick with ADAMANT, the cement that makes the joints stronger than the brick they bond.

To prove the outstanding strength of ADAMANT impartial laboratory modulus tests were made on 5 test joints by a leading technical institute that showed . . .

ADAMANT

FIRE BRICK CEMENT has a BONDING STRENGTH

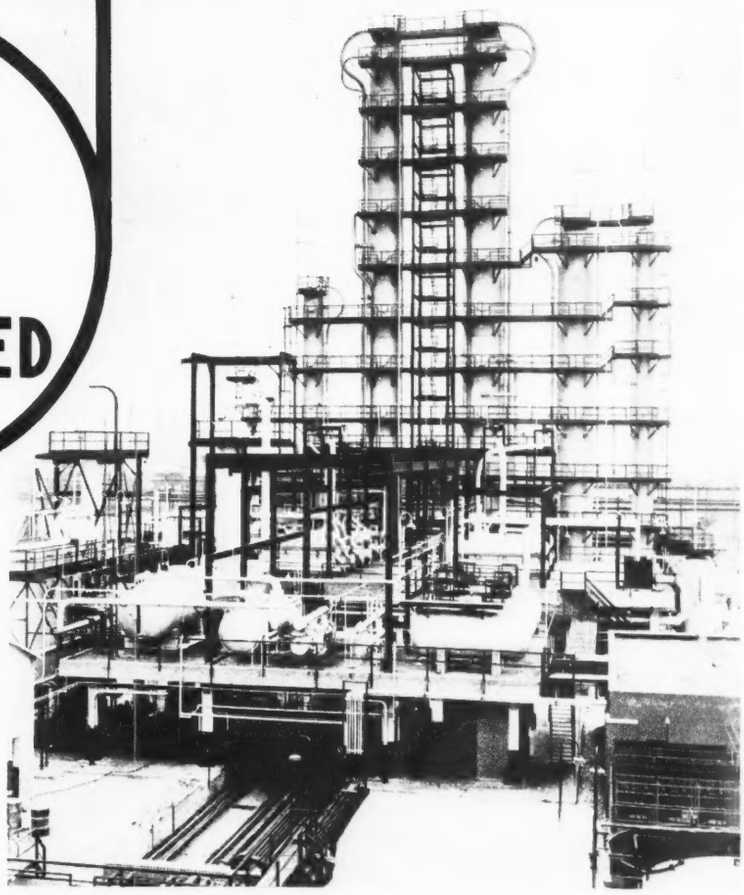
of 800 lbs. per sq. in. at room temperature. 1270 lbs. per sq. in. at 2600° F

ADAMANT has a P.C.E. of over 3,000° F. This great strength assures added furnace operating time with lower maintenance costs. Let us give you all the facts, write

BOTFIELD REFRACTORIES COMPANY

Makers of ADAPRODUCTS, Swanson & Clymer Sts., Philadelphia, Pa. In Canada, Canadian Botfield Refractories Co., Ltd., 171 Eastern Ave., Toronto.

100% Carey INSULATED



GULF DOUBLES ITS FACILITIES FOR MANUFACTURE OF AVIATION GASOLINE AT PORT ARTHUR REFINERY

Keeping pace with the rapid industrial expansion of the Southwest, the Gulf Oil Corporation has added a new unit to its Port Arthur, Texas refinery. The increased facilities represent a major investment and were made to meet the normal domestic demand for aviation gasoline.

CAREY Heat Insulations were used throughout in this improvement.

The economics of present-day refining processes call for higher and still higher efficiency—and this means more and better insulations. The extensive use of CAREY Insulations by leaders of the industry is abundant evidence of the ability of these products to meet every requirement and to effect maximum savings.

Constant research and improvement; more than a half century of manufacturing experience; the practical knowledge gained from contact with every insulation problem—these are CAREY assets that rule out experimentation and assure dependable results. You're always SAFE with CAREY. A nation-wide organization is at your service. Write Department 16 for Insulation Catalog.

THE PHILIP CAREY COMPANY • Lockland, Cincinnati, Ohio
Dependable Products Since 1873
IN CANADA: THE PHILIP CAREY COMPANY, LTD. Office and Factory: LENNOXVILLE, P. Q.

Fyr-Feeder **Multi-Burner**
SPREADER STOKERS

EMPLOY THE SIMPLE, PRACTICAL
Spray-Spred
METHOD OF COAL FIRING
(EXCLUSIVE WITH **Fyr-Feeder**)

Coal from Hopper is fed mechanically through front furnace wall to each of the many Burner-Spreaders which comprise a FYR-FEEDER Stoker. These Burners are usually spaced on 11" or 14½" centers across the furnace width.

At the foot of each Burner Incline, the rolling coal meets a stream of air. Only one ounce of air pressure is used to Spray-Spred coal over a grate 9' long.

Fyr-Feeder *Advantages*

★ Multi-Burners assure Perfect Spreading of Coal on Grates.

★ The Propelling Air surrounds each particle of coal and burns fines instantly in suspension.

★ Combustion acceleration is accomplished by over-fire air turbulence and the eddies produced by the millions of projected coal particles on their way to the grates.

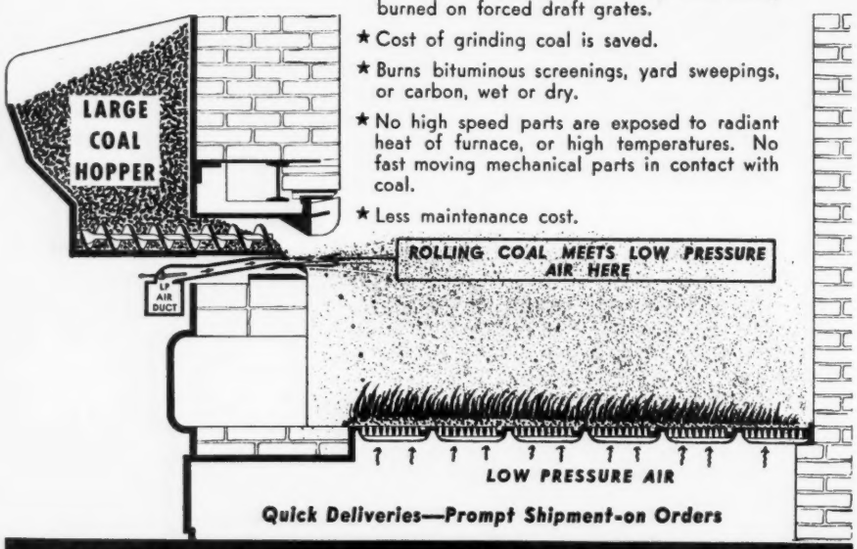
★ The advantages of pulverized coal burning plus the advantages of an additional fire and the radiant heat produced by coal being burned on forced draft grates.

★ Cost of grinding coal is saved.

★ Burns bituminous screenings, yard sweepings, or carbon, wet or dry.

★ No high speed parts are exposed to radiant heat of furnace, or high temperatures. No fast moving mechanical parts in contact with coal.

★ Less maintenance cost.



Quick Deliveries—Prompt Shipment-on Orders

AMERICAN COAL BURNER COMPANY
FOUNDED 1918
Builders of thousands of over-feed stokers
151 E. SUPERIOR ST. CHICAGO, ILL.

static accumulations built up in belts, especially those operating on insulated pulleys, is blamed for an estimated annual fire loss of $3,000,000, according to the National Fire Protection Association. In aviation the flow of air across the body of a plane in flight creates a charge which, if it were not controlled, would reduce the efficiency of de-icing equipment; the same applies to airplane tires.

The turbulent flow of gasoline through hose in loading and delivery operations of the oil industry also creates an obvious danger; filling stations face a static hazard because automobile bodies become charged in the same way as planes. In this last instance, the discharge would be particularly hazardous but for various elementary protective measures adopted widely.

Rubber Conductors

In some applications the accumulation of static charges is not hazardous; in others satisfactory grounding connections can be readily applied so that no hazard results. However, in a number of other applications it is necessary for the successful performance of the equipment that the rubber composition provide a path for the discharge of static. The successful development of applications in this category is dependent upon the ability of the rubber technologist to provide compositions of various degrees of conductivity to bleed off static charges at a rate sufficiently high to prevent their accumulation to the danger point. In addition to their function as moderately good conductors, these compounds, because of their higher conductivity, will generate less static voltage under the same frictional conditions.

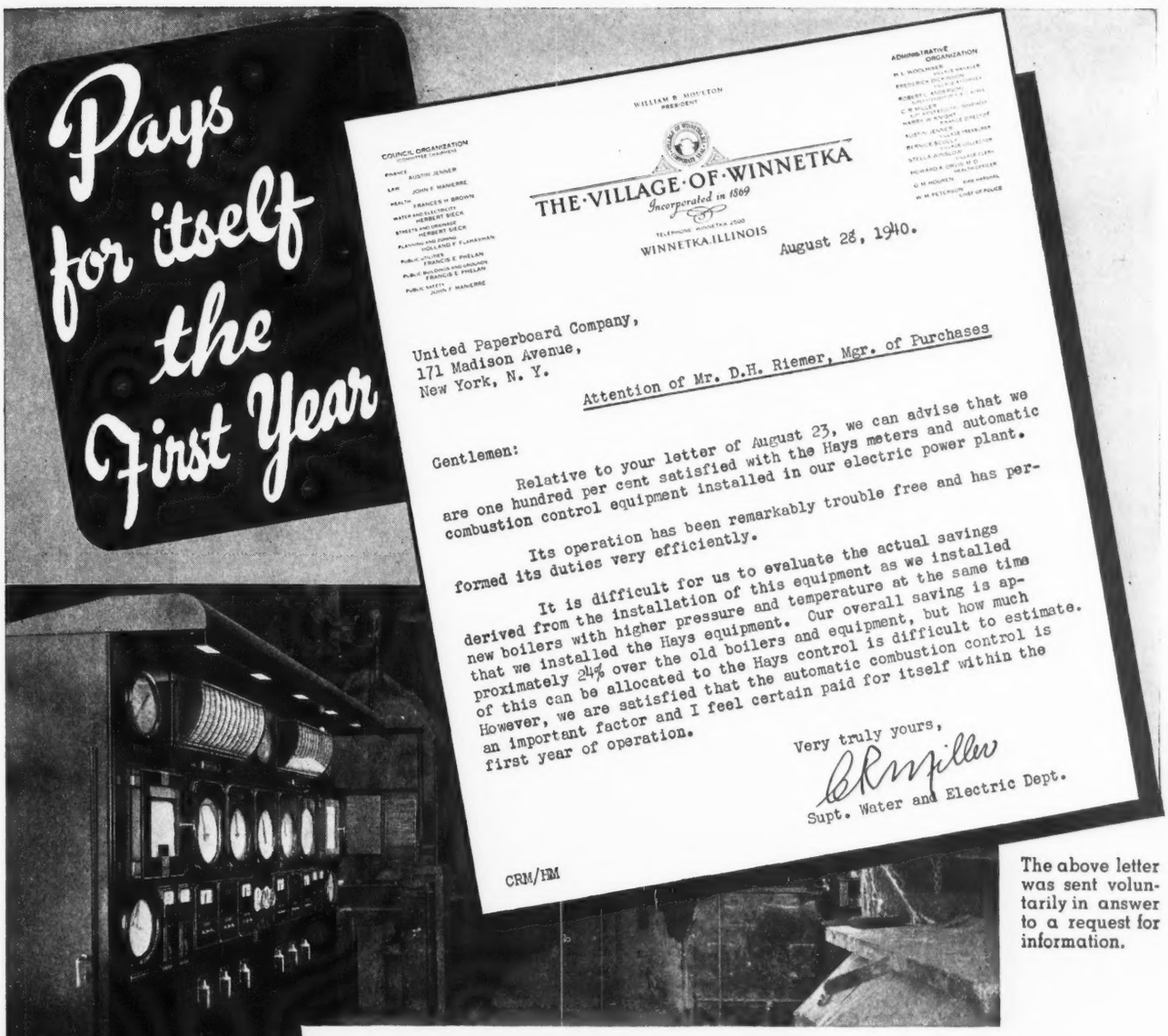
The development of semi-conducting rubber and synthetic rubber compounds has been the means of solving a number of important problems involving hazards due to static discharges. Undoubtedly the availability of these materials will now be the means of solving many more.

The Engineer Writes a Report

THOSE WHO HAVE VISITED a number of power plants or who have among their acquaintances a considerable number of operating engineers, will be only too familiar with the following complaints.

"I wish I had half what I could save in my plant, but the owners won't spend a dime for new equipment." ,

Pays for itself the First Year



THE·VILLAGE·OF·WINNETKA
Incorporated in 1869
WINNETKA, ILLINOIS

August 28, 1940.

United Paperboard Company,
171 Madison Avenue,
New York, N. Y.

Attention of Mr. D.H. Riemer, Mgr. of Purchases

Gentlemen:

Relative to your letter of August 23, we can advise that we are one hundred per cent satisfied with the Hays meters and automatic combustion control equipment installed in our electric power plant.

Its operation has been remarkably trouble free and has performed its duties very efficiently.

It is difficult for us to evaluate the actual savings derived from the installation of this equipment as we installed new boilers with higher pressure and temperature at the same time that we installed the Hays equipment. Our overall saving is approximately 24% over the old boilers and equipment, but how much of this can be allocated to the Hays control is difficult to estimate. However, we are satisfied that the automatic combustion control is an important factor and I feel certain paid for itself within the first year of operation.

Very truly yours,

Supt. Water and Electric Dept.

CRM/HM

The above letter was sent voluntarily in answer to a request for information.

A MUNICIPAL light plant in a mid-western city, through a modernization and expansion program including Hays Automatic Combustion Control, improved its operating efficiency around 24%. Steam pressure was raised from 225 lbs. to 450 lbs., total temperature from 500° F. to 750° F. and fuel consumption per kw.-hr. output was reduced from 2.32 lbs. to 1.73 lbs. Efficient and economical combustion with practically no smoke or fly-ash is maintained by the Hays Automatic Control as well as a constant steam pressure regardless of load fluctuations.

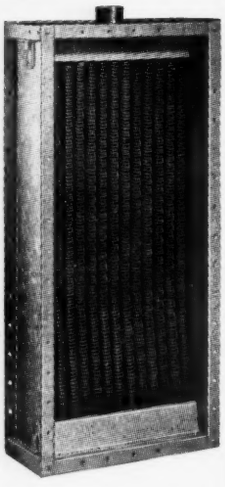
Hays Engineering organizations throughout the country are ready to advise you how automatic combustion control may be able to improve the operating conditions in your own power plant—no obligation. Write us.

NOTE TO ENGINEERS:

Tear off the bottom of this ad and mail with your name and address to Hays Corporation and we will send you a copy of "Automatic Combustion Control and Its Relation to Lower Steam Costs."

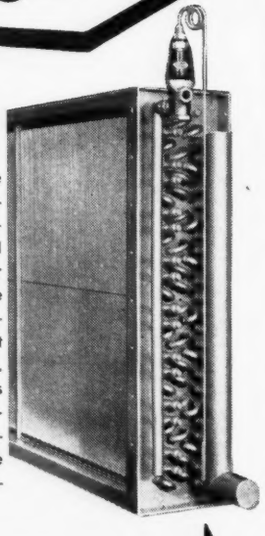
The HAYS CORPORATION
SINCE 1901
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A

fedders
HEATING COILS



● Large cylindrical headers...full-floating protection against expansion...top header tri-point supported by center anchorage brackets and drop forged bronze trunnions . . . knee action relief of differential expansion among tubes...scale breaker tube orifices . . . floating-type tube supports . . . built in a complete range of standard sizes

fedders
COOLING COILS



● Built for use with either refrigerants or water . . . equipped with flat fins for rapid air-side condensate removal...efficient performance . . . result of 45 years heat transfer experience. Available in a wide range of standard sizes.

FEDDERS MANUFACTURING CO., INC.
Air Conditioning Division
63 Tonawanda St., Buffalo, N. Y.

"I know there is a lot of waste here but it takes a little money to fix things up. They just won't listen to me."

"Sure we could cut over-all cost of furnace brickwork. but the first cost would be a little higher and the boss just won't hear of it."

The same story is told over and over in thousands of boiler plants, large and small, though it is probable that it is heard more in the small and medium-sized industrial plant. There is some truth and some evasiveness in these stories; the latter is usually unintentional on the part of the engineers.

The "boss" may be the general manager, purchasing agent, president, owner, or other executive. The one outstanding fault on the part of most of these engineers is that they don't talk the boss's language. This does not mean necessarily good diction, excellence of grammar, and fluency of speech. It does mean concise facts and figures presented in a businesslike way.

What, then, is the best way to present these facts and figures in order to get action? The answer is simple. Write a report.

The report should be concise—but complete, neat, and easily understood.

In the introductory paragraph state the purpose of the report. This may cover conditions leading up to the time of the report. Describe the conditions briefly. Use an itemized list in tabular form if possible.

The adverse conditions existing may well be listed in a column titled "Disadvantages under Present System." The other side of the case should be presented in an adjacent column listing the advantages under the proposed changes.

Following this, it would be well to include a paragraph describing just how the changes would be carried out, time, and any special problems, necessary equipment, etc.

Then should come a comparison in costs as at present and under the proposed change, savings per month, per year, or over the estimated life of the equipment.

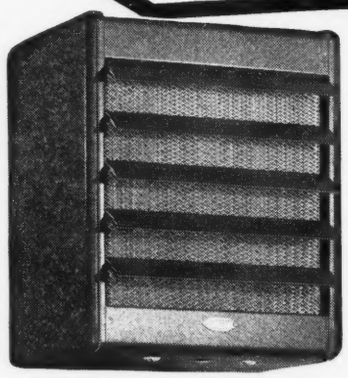
A typical brief report covering the need of refractory changes is given as follows:

REPORT COVERING REFRACTORY COSTS

A study of our expenses for brickwork maintenance in Boiler No. 2 indicate that we may effect a substantial reduction. We have been using XYZ firebrick for two years. Patching every three or four months has been necessary, and present indications are that the effective life of the brickwork will not exceed three years.

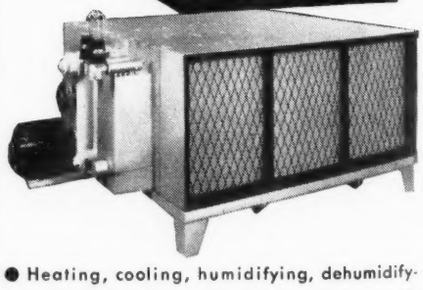
Among the various makes of firebrick

fedders
UNIT HEATERS



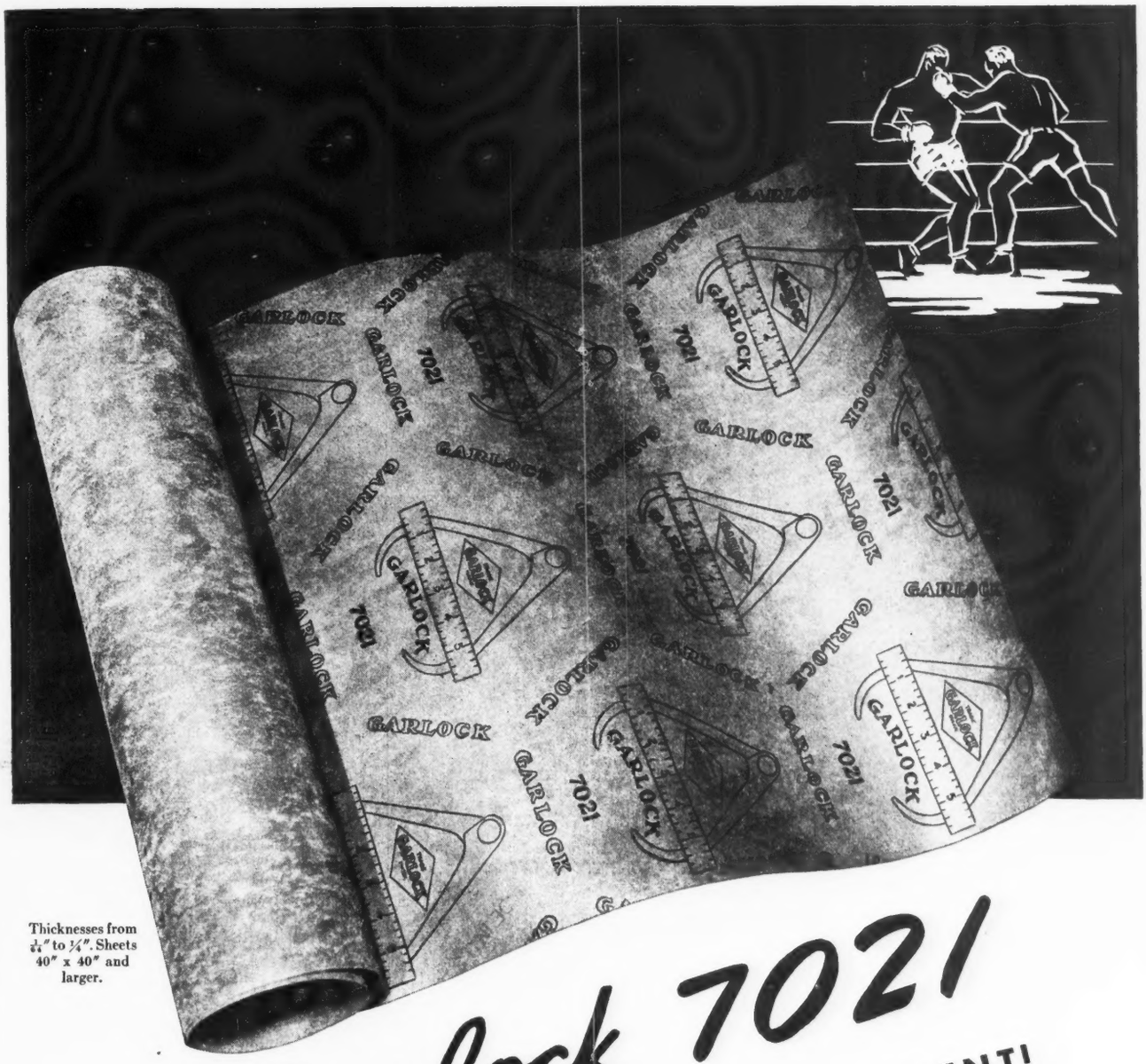
● Streamline tubes... individual non-clogging fins ... patented full-floating mounting eliminates destructive stresses... relief of differential expansion among tubes . . . rugged monopiece modern styled cabinets. Built in 25 basic sizes.

fedders
AIR CONDITIONERS



● Heating, cooling, humidifying, dehumidifying and air-filtering in any combination are available with Fedders All-Season Air-Conditioning Units. Built in seven basic standard models from 1 to 25 tons.

FEDDERS MANUFACTURING CO., INC.
Air Conditioning Division
63 Tonawanda St., Buffalo, N. Y.



Thicknesses from 1/64" to 1/4". Sheets 40" x 40" and larger.

Garlock 7021

WILL TAKE PLENTY OF PUNISHMENT!

Under the most severe conditions—such as super-heated high pressure steam and light oils at high temperatures—Garlock 7021 Compressed Asbestos Sheet Packing will *stand up* where ordinary gasketing materials fail. Avoid gasket failures and expensive shut-downs—use Garlock 7021.

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK

In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

GARLOCK GIVES YOU ALL 3

1. Dependability
2. Long Life
3. Economy

Garlock-the Standard Packing of the World

EVERY PLANT EXECUTIVE IN AMERICA IS URGED TO ACCEPT THIS BOOK

WE BELIEVE you will see how to spend less money for packings, devote less time to maintenance, and operate at higher efficiencies, once you have accepted your free copy of this R/M catalog.

For the Raybestos-Manhattan packings it shows are the result of 40 years' experience in fabricating asbestos and rubber. The line it contains is the smallest complete line on record, since all duplicates are eliminated. The materials are fully illustrated, cross-indexed according to the jobs they perform, and carefully described. And all of them are immediately available through a nearby R/M distributor.

Let R/M packings whip your horsepower into line. Own this free catalog. Ask your local R/M outlet, or write us direct for your copy.

INDUSTRIAL SALES DIVISION
RAYBESTOS-MANHATTAN, INC.
Makers of Packings for Every Industrial Use
BRIDGEPORT, CONN. MANHEIM, PA. NORTH CHARLESTON, S. C. PASSAIC, N. J.

available for our service is the ABC firebrick. This brick is used in the boilers at the John Doe Co, the Blank Corp, and at the J C Smith plant under operating conditions similar to ours. Investigation shows that patching but once a year is necessary and that an average life of at least five years may be expected.

Operating characteristics are compared.

XYZ BRICKWORK	ABC BRICKWORK
Spalls (breaks) badly within three months.	Stands up a year between repairs.
Shutdown for repairs necessary every 12 weeks.	Shutdown for repairs but once a year.
Vital parts of boiler may be exposed to damage from overheating by failure of brick arch.	Strength and safety of arch structure is greater.

From the obvious advantages of ABC refractory, it should be of interest to consider costs. A comparison of costs follows.

COST OF REFRACTORY WALLS	COST OF NEW WALLS
Installed (present type), $1,500.	ABC firebrick $2,000.
Total cost of repairs over three years' life, $550.	Total anticipated cost of repairs over five years, $500.
Total cost over life of walls, $2,050.	Total cost over life of walls, $2,500.
Cost per year, $683.33.	Cost per year, $500.

Savings per year, $183.33.
Savings per life of new walls, $916.65.
It is felt that the proposed change represents a wise investment at the time the present refractory is renewed. That will be very shortly after the end of the current heating season. Signed — John Brown, April 4, 1941.

A report such as this does far more to attain results than any amount of complaining, arguing or verbal discussion. Try it if you have the opportunity.

Canton, Mass. H M SPRING

Q—What is the difference between a cap screw and a tap bolt?

A—A cap screw may have a slotted head for use with a screw driver or it may have a hex or square head. It may be threaded for part of the body length or to the full length, as for certain U. S. Navy standards. Tap bolts have square or hex heads and are threaded for the full length of the body.

Q—What is the difference between actual evaporation and equivalent evaporation?

A—Actual evaporation is the num-

THE MOTOR YOU ASKED FOR IS STRONG ON PROTECTION

New G-E TRI-CLAD MOTOR

1

Extra Protection

AGAINST PHYSICAL DAMAGE

A truly modern motor must withstand accidental blows, flying chips, dripping liquids, and occasional bumps in moving or mounting. We built the Tri-Clad motor to meet such threats of damage!

We made the frame and end shields of cast iron, using channel and rib sections for strength without excessive weight or bulk; we cast the sturdy, rigid feet integrally with the frame. We completely enclosed the upper portion and carefully baffled all ventilating openings to protect vital motor parts. The bearings have dust-tight cast-iron housings. And the finishing touch—we gave the motor a tough coat of paint to protect against rust and corrosion.

The Tri-Clad motor is fully protected against the accidental ill-treatment some motors encounter all the time, and which *all* motors encounter some of the time. As a safeguard against production interruptions, as a prime factor in lowering costs, this new motor means extra profit protection, too.

Make your next induction motors Tri-Clad. General Electric, Schenectady, N.Y.

"BUILT FOR PROTECTION FIRST . . . . . TO LAST"

2

Extra Protection

AGAINST ELECTRICAL BREAKDOWN

New stator windings of Formex wire give extra protection internally against moisture, oil, abrasion, and heat aging. New synthetic impregnating and protecting varnishes make a rigid unit with a hard finish.

3

Extra Protection

AGAINST OPERATING WEAR AND TEAR

Sleeve bearings of new design have long life and great load capacity because of new proportions and oil distributing system. The one-piece cast-aluminum rotor winding, with fans cast integrally, is practically indestructible.

GENERAL ELECTRIC

750-49-8058

Readable–Anywhere!

WESTON

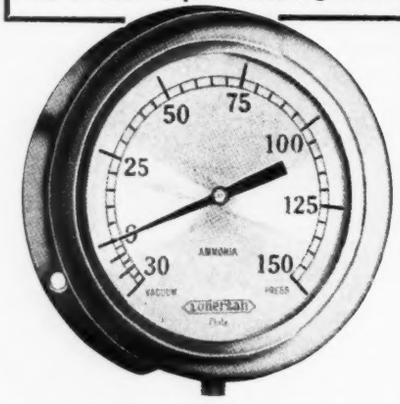
GAUGE-TYPE THERMOMETERS

The large, gauge-type scales of WESTON Thermometers insure more *accurate* readings, too; especially where thermometers are mounted 'way *above* or *below* eye-level . . . or in those hard-to-get-at places. That's why they're being so widely used on steam, oil and water lines . . . and elsewhere throughout the power plant. And WESTONS are easy to mount . . . and less subject to damage or breakage . . . because of their rugged, all-metal construction. Available in both angle and straight stem types . . . scale diameters from 3" to 6" . . . stem lengths from 2½" to 24". Accuracy guaranteed within 1%. Bulletin giving complete details gladly sent on request.

WESTON ELECTRICAL INSTRUMENT CORPORATION
679 Frelinghuysen Avenue, Newark, New Jersey

Model SAG—AMMONIA GAUGE

Made expressly for use with ammonia or other liquids affecting brass



Tubes are made of a very high grade steel and carefully tempered, insuring uniformity and reducing the chances of spring setting to a minimum. Movement made of Monel; non-corrodible. Back connection furnished, if desired.

For low pressures, graduation is 150 lb. pressure and 30" vacuum; for high pressures, 300-lb. pressure and 30" vacuum.

Write for complete catalog.

Lonergan

GAUGES • VALVES • SPECIALTIES

J. E. LONERGAN CO.
Race & Second Streets, Philadelphia, Pa.
300 SPECIALTIES for POWER PLANTS—SINCE 1872

YOUR

Dependable Guide

. . . to the big things and little things done each month by operators and manufacturers across the country to raise plant efficiencies, cut costs, and reduce trouble.

It Pays You to

Read POWER Regularly

ber of lb of feedwater converted to steam at existing boiler pressure and final steam temperature, each hour. To get equivalent evaporation this figure is converted to lb of water at 212 F turned into steam at 212 F.

Crane Builders Given Priorities

A limited blanket priorities rating has been given nine builders of electric traveling cranes to speed work in shipyards and other vital defense plants. Included in the equipment these builders may obtain in priority over commercial orders are electric motors, switches, controllers and connections.

This is the first general priorities ratings which has been given to an industry to enable it to get first call on all electrical equipment widely used by utilities. Use of priority rating by the crane builders is limited specifically to defense orders. The order requires submission of the crane concerns' books monthly, showing the articles they have scheduled for delivery the following month.

High Bridge Station to Add 100,000 kw

Installation of a 50,000-kw turbine-generator now nearing completion at the Schenectady works of General Electric Co, and a duplicate unit on which construction will soon begin, will more than double the generating capacity of the Northern States Power Co's High Bridge plant at St. Paul. Both units will be housed in a $4,000,000 addition being made to the plant.

The two new turbine-generators are of the tandem-compound, double-flow type, with hydrogen-cooled generators. Steam conditions will be 850 lb g, 900 F. Total plant capacity, after installation of the new units, will be 170,000 kw.

CORRECTION

In the article "Evaluating Corrosion Resistance of Modern Turbine Oils", pages 66-69, March POWER, Fig. 5, representing the effect of adding used oil to new oil fills, was incorrectly labelled to show "10%" admixture in place of "15%" and vice versa. The effect of this error implied that the smaller amount of used oil produced a greater loss in effective oil life, obviously not intended by the authors or indicated by the tests.